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Kim

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(54) **ARTIFICIAL INTELLIGENCE APPARATUS AND METHOD FOR DETERMINING INATTENTION OF DRIVER**

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G06K 9/00	(2006.01)
G06K 9/62	(2006.01)
B60N 2/00	(2006.01)
G06N 3/04	(2006.01)
G06N 3/08	(2006.01)
B60W 40/08	(2012.01)

(52) **U.S. Cl.**

CPC ***G06K 9/00845*** (2013.01); ***B60N 2/002*** (2013.01); ***B60W 40/08*** (2013.01); ***B60W 50/14*** (2013.01); ***G06K 9/00315*** (2013.01); ***G06K 9/6256*** (2013.01); ***G06N 3/04*** (2013.01); ***G06N 3/08*** (2013.01); *B60W 2040/0818* (2013.01); *B60W 2050/143* (2013.01)

(58) **Field of Classification Search**

CPC G06K 9/00845; G06N 3/04

See application file for complete search history.

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(57) **ABSTRACT**

Disclosed herein an artificial intelligence apparatus for determining inattention of a driver including a vibration sensor or a gyro sensor configured to sense movement of a driver's seat of a vehicle, a camera configured to receive image data including a face of a driver, a communication modem configured to receive vehicle status information from an ECU (Electronic Control Unit) of the vehicle, and a processor configured to generate movement information of the driver's seat using vibration sensor information received from the vibration sensor or gyro sensor information received from the gyro sensor, generate driver status information corresponding to the driver from the received image data, determine whether the driver is in an inattention status based on the movement information of the driver's seat, the driver status information and the vehicle status information, and output an inattention alarm if the driver is in the inattention status.

7 Claims, 15 Drawing Sheets

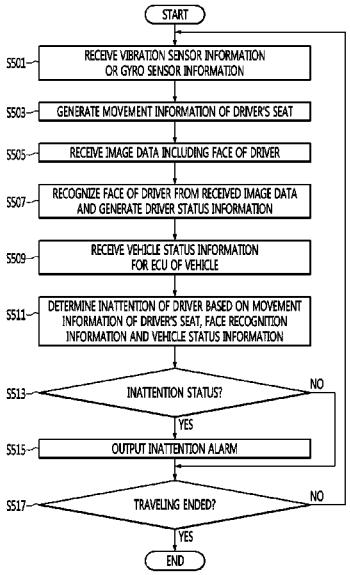


FIG. 1

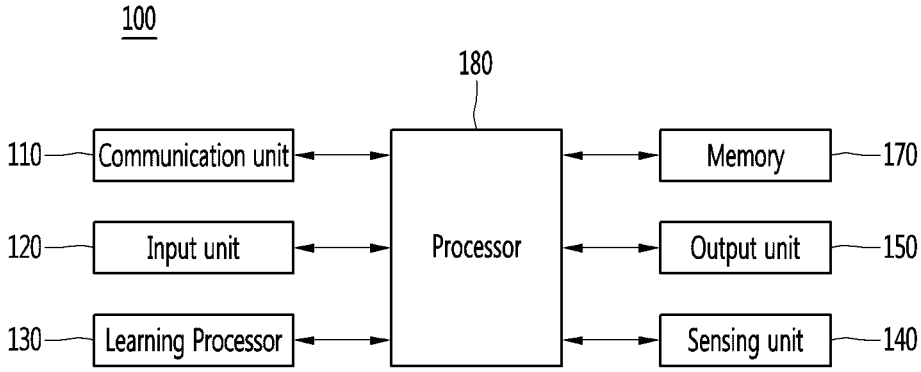

100
180
110
Communication unit
120
Input unit
130
Learning Processor
Processor
Memory
170
Output unit
150
Sensing unit
140

FIG. 2

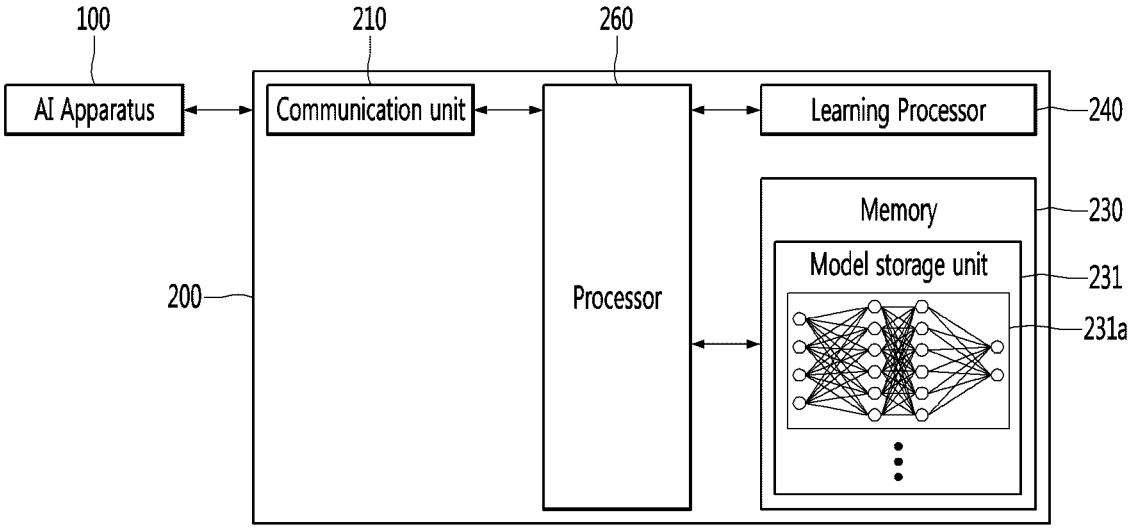

100
210
260
AI Apparatus
Communication unit
Learning Processor
240
Memory
230
Model storage unit
231
231a
200
Processor

FIG. 3

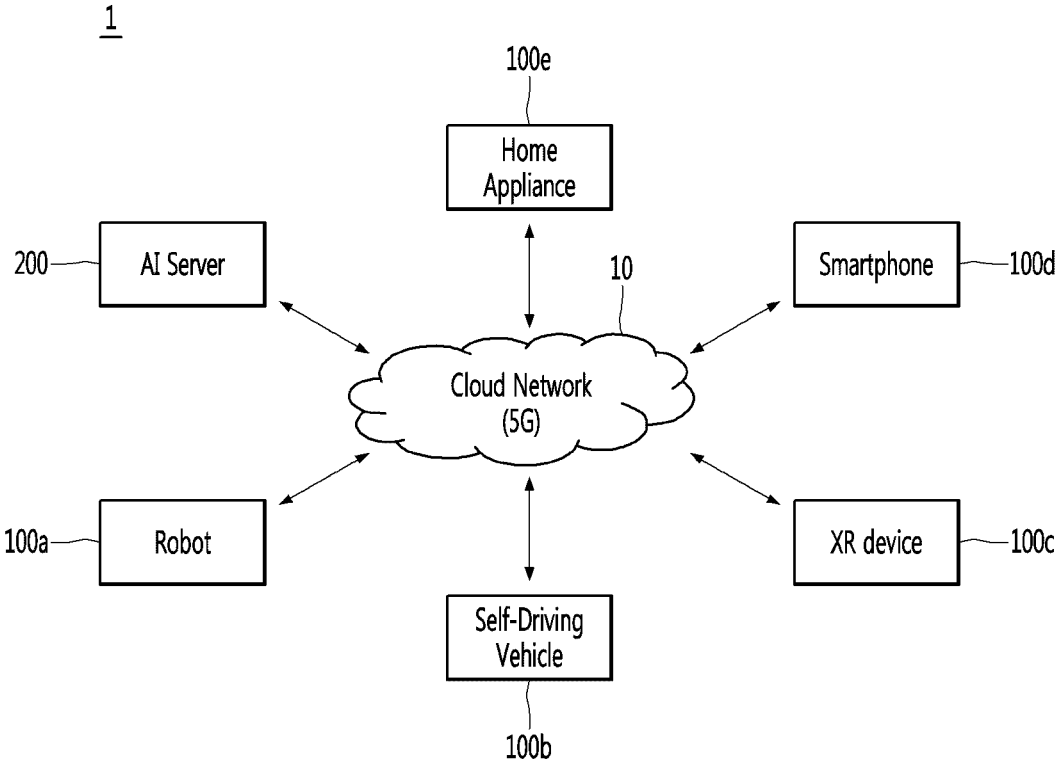

1
100e
Home Appliance
200
AI Server
10
Smartphone
100d
Cloud Network (5G)
100a
Robot
XR device
100c
Self-Driving Vehicle
100b

FIG. 4

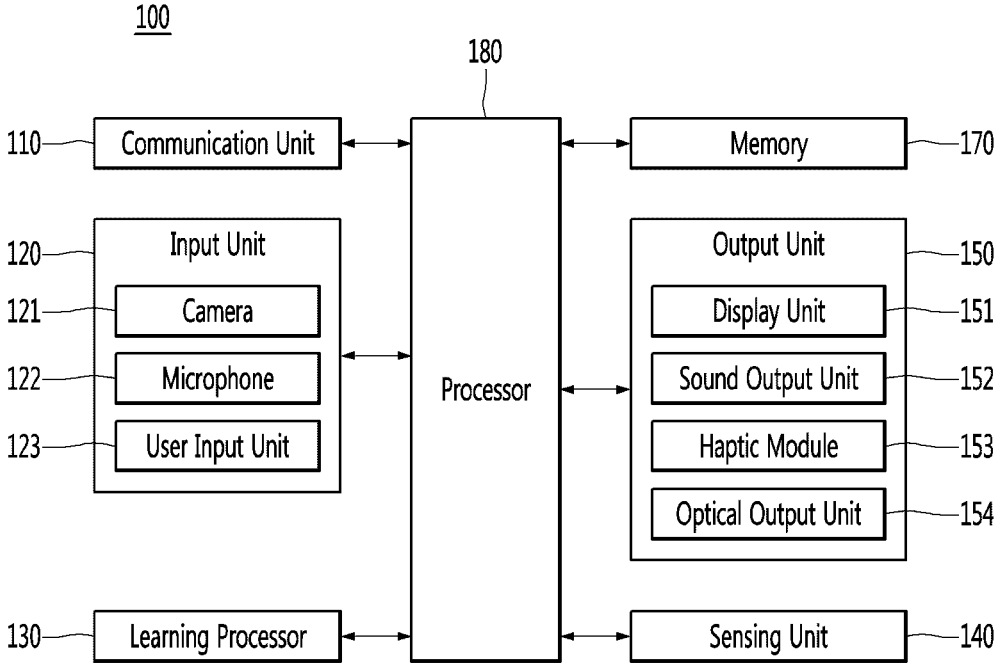

100
180
110
Communication Unit
Memory
170
120
Input Unit
121
Camera
122
Microphone
123
User Input Unit
Processor
Output Unit
150
Display Unit
151
Sound Output Unit
152
Haptic Module
153
Optical Output Unit
154
130
Learning Processor
Sensing Unit
140

FIG. 5

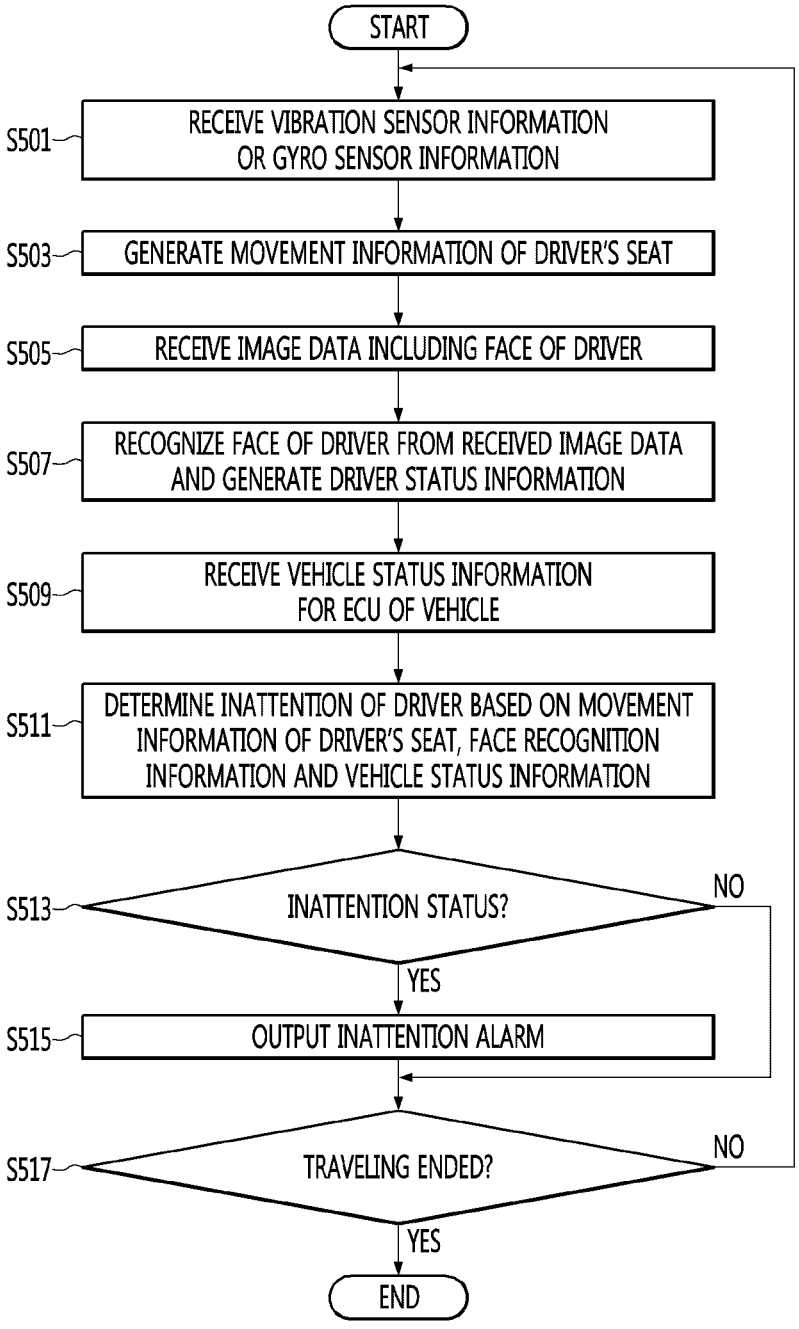

START
S501
RECEIVE VIBRATION SENSOR INFORMATION OR GYRO SENSOR INFORMATION
S503
GENERATE MOVEMENT INFORMATION OF DRIVER'S SEAT
S505
RECEIVE IMAGE DATA INCLUDING FACE OF DRIVER
S507
RECOGNIZE FACE OF DRIVER FROM RECEIVED IMAGE DATA AND GENERATE DRIVER STATUS INFORMATION
S509
RECEIVE VEHICLE STATUS INFORMATION FOR ECU OF VEHICLE
S511
DETERMINE INATTENTION OF DRIVER BASED ON MOVEMENT INFORMATION OF DRIVER'S SEAT, FACE RECOGNITION INFORMATION AND VEHICLE STATUS INFORMATION
S513
INATTENTION STATUS?
NO
YES
S515
OUTPUT INATTENTION ALARM
S517
TRAVELING ENDED?
NO
YES
END

FIG. 6

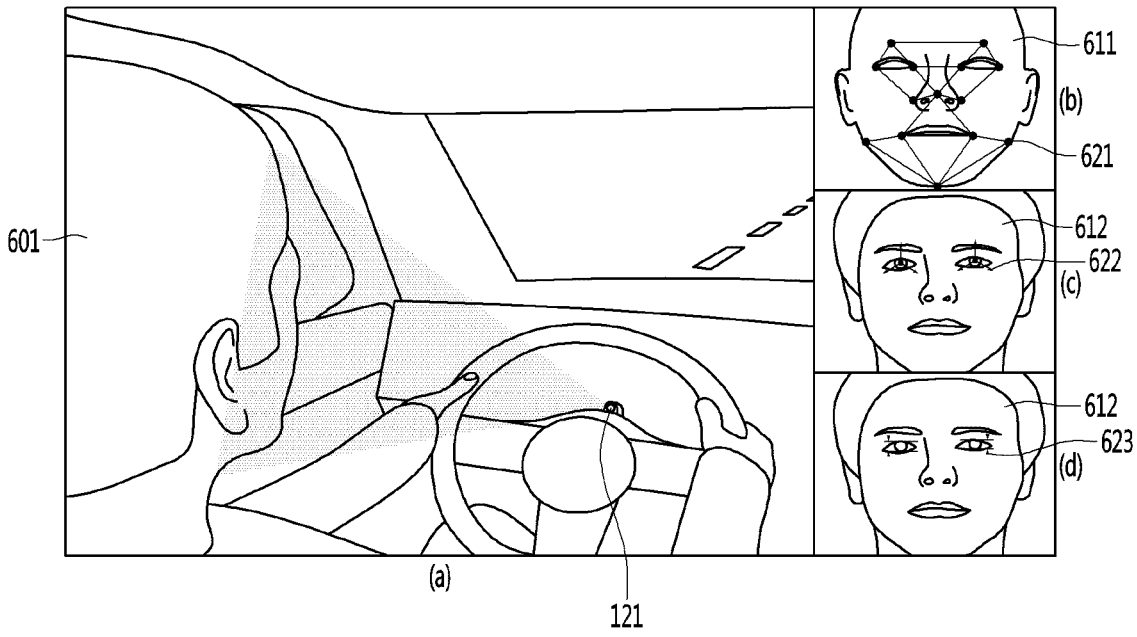


FIG. 7

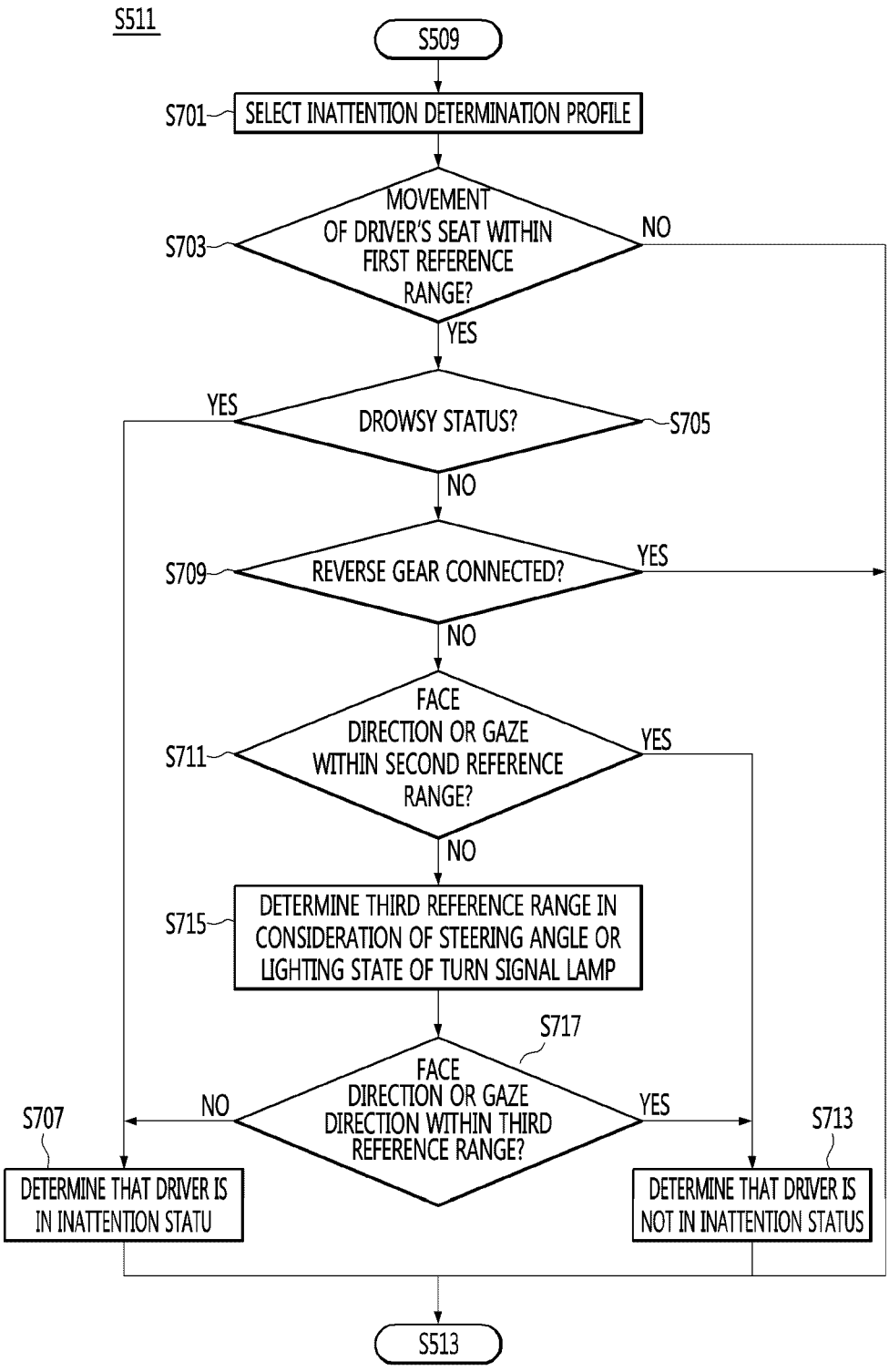

S511
S509
S701
SELECT INATTENTION DETERMINATION PROFILE
S703
MOVEMENT OF DRIVER'S SEAT WITHIN FIRST REFERENCE RANGE?
NO
YES
YES
DROWSY STATUS?
S705
NO
S709
REVERSE GEAR CONNECTED?
YES
NO
S711
FACE DIRECTION OR GAZE WITHIN SECOND REFERENCE RANGE?
YES
NO
S715
DETERMINE THIRD REFERENCE RANGE IN CONSIDERATION OF STEERING ANGLE OR LIGHTING STATE OF TURN SIGNAL LAMP
S717
FACE DIRECTION OR GAZE DIRECTION WITHIN THIRD REFERENCE RANGE?
NO
YES
S707
DETERMINE THAT DRIVER IS IN INATTENTION STATU
S713
DETERMINE THAT DRIVER IS NOT IN INATTENTION STATUS
S513

FIG. 8

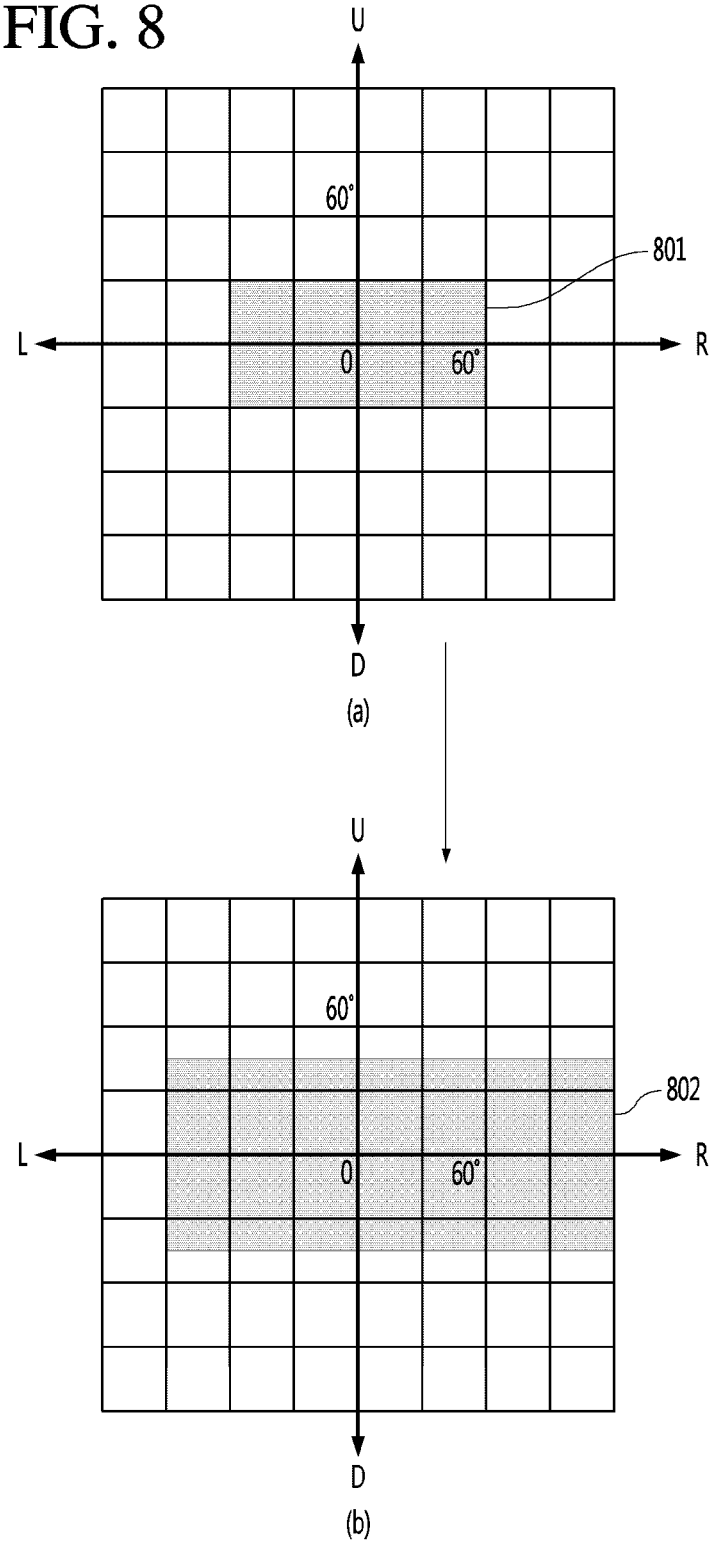


FIG. 9

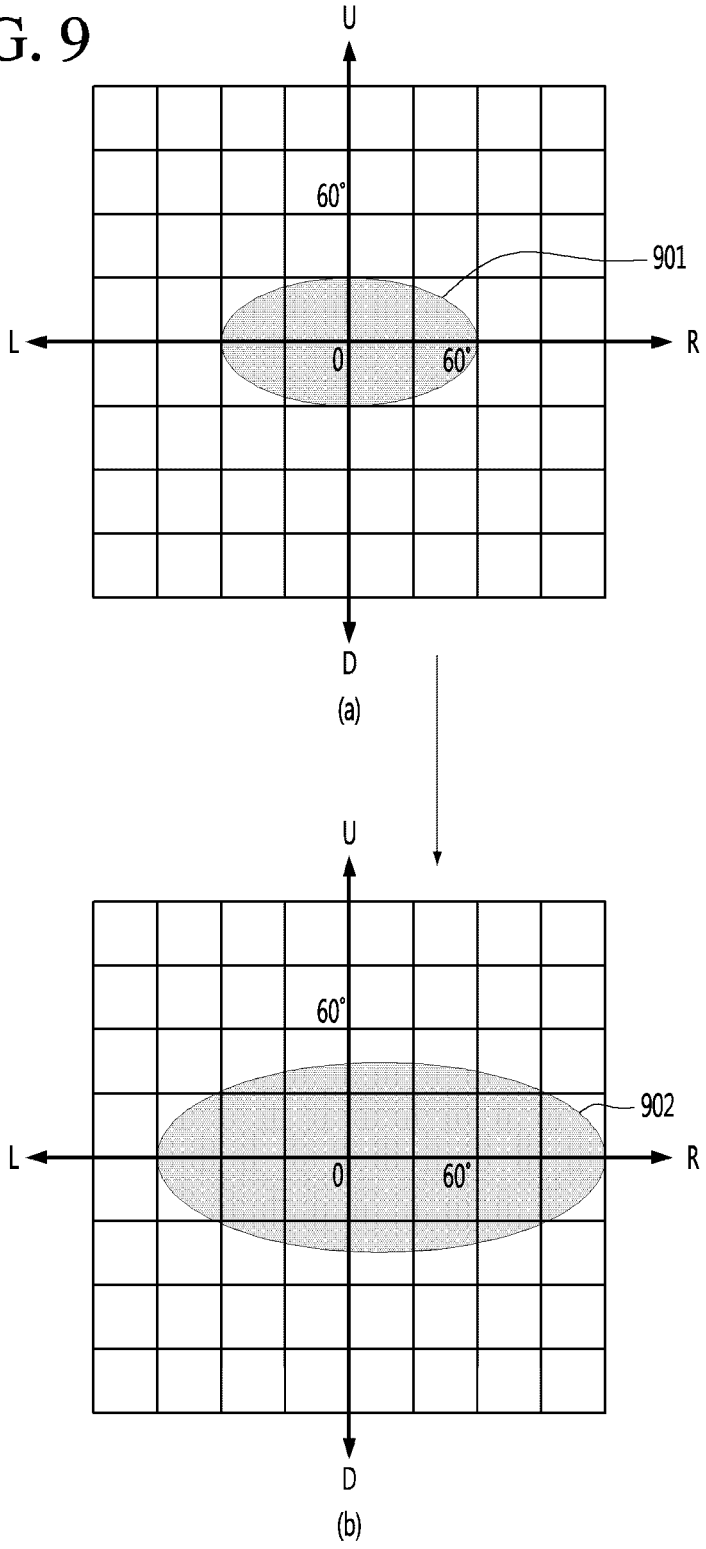
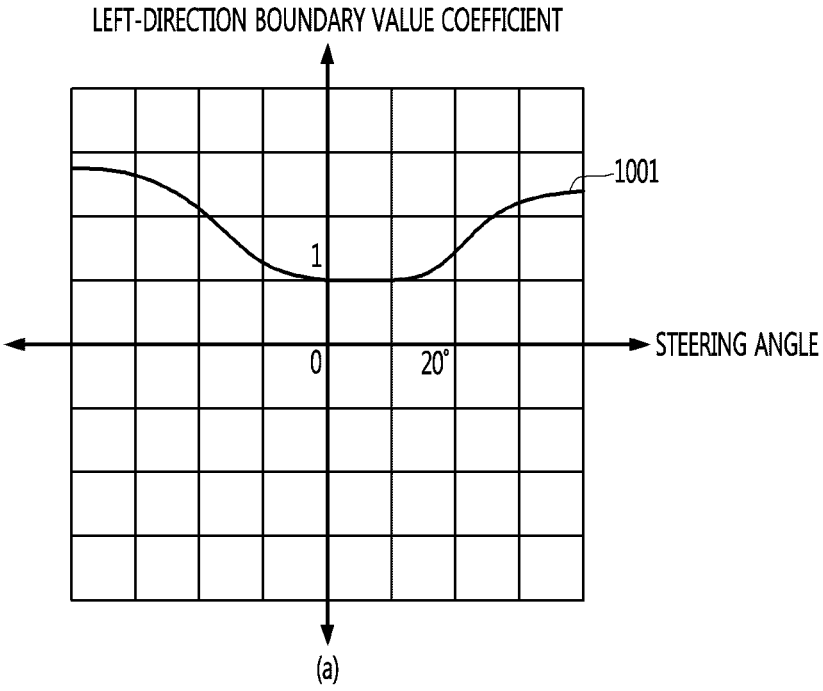


FIG. 10


LEFT-DIRECTION BOUNDARY VALUE COEFFICIENT
1001
1
0
20°
STEERING ANGLE
(a)

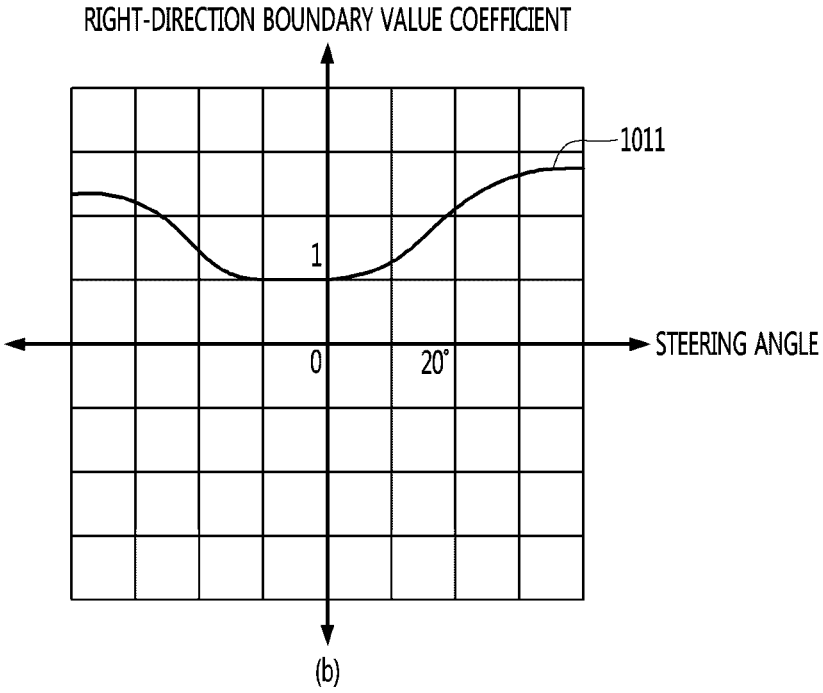

RIGHT-DIRECTION BOUNDARY VALUE COEFFICIENT
1011
1
0
20°
STEERING ANGLE
(b)

FIG. 11

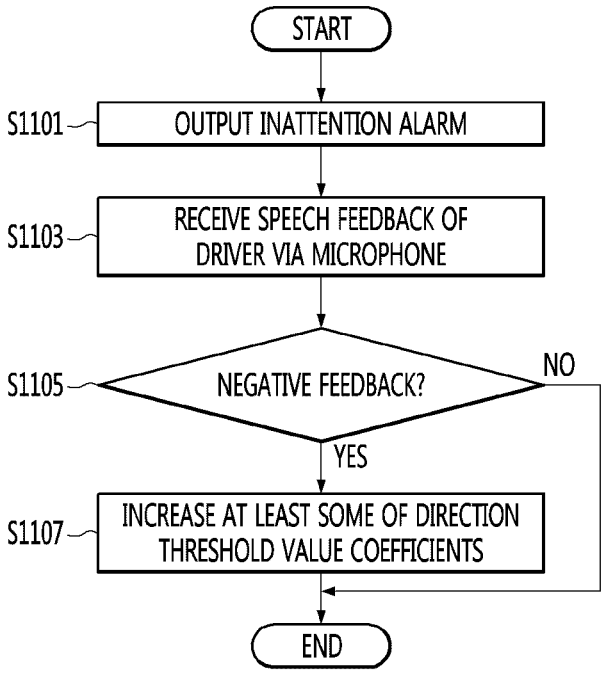
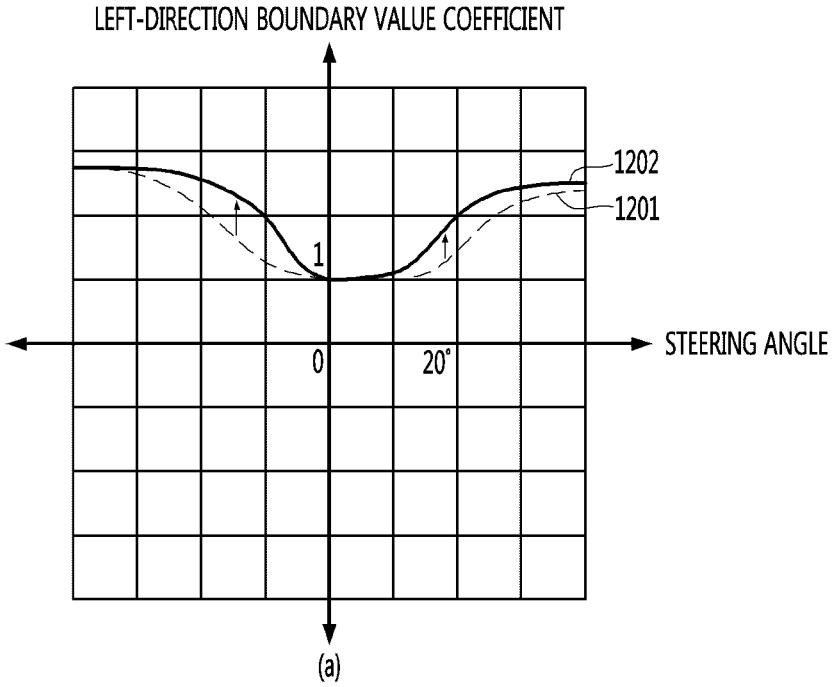

START
S1101
OUTPUT INATTENTION ALARM
S1103
RECEIVE SPEECH FEEDBACK OF DRIVER VIA MICROPHONE
S1105
NEGATIVE FEEDBACK?
NO
YES
S1107
INCREASE AT LEAST SOME OF DIRECTION THRESHOLD VALUE COEFFICIENTS
END

FIG. 12


LEFT-DIRECTION BOUNDARY VALUE COEFFICIENT
1202
1201
1
0
20°
STEERING ANGLE
(a)

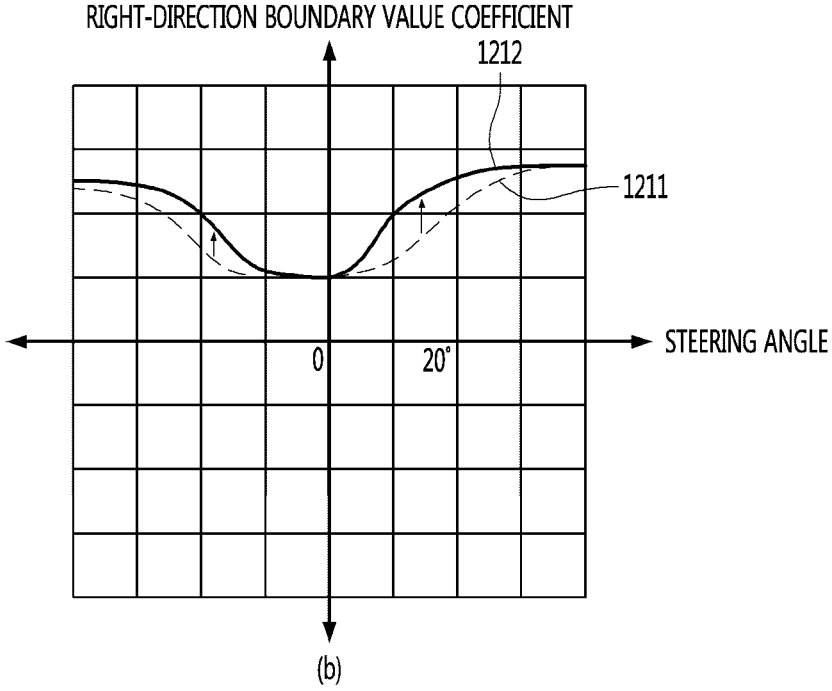

RIGHT-DIRECTION BOUNDARY VALUE COEFFICIENT
1212
1211
0
20°
STEERING ANGLE
(b)

FIG. 13

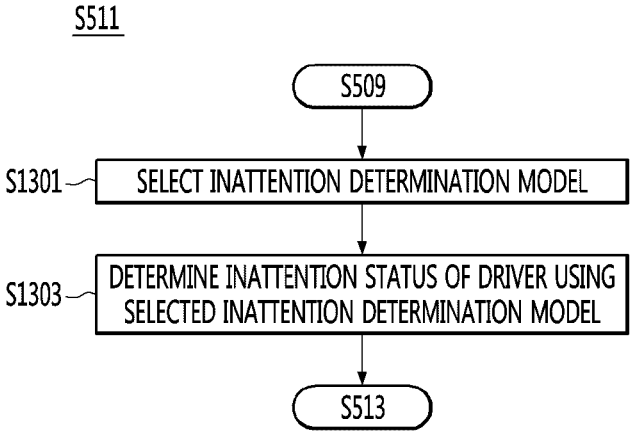

S511
S509
S1301
SELECT INATTENTION DETERMINATION MODEL
S1303
DETERMINE INATTENTION STATUS OF DRIVER USING SELECTED INATTENTION DETERMINATION MODEL
S513

FIG. 14

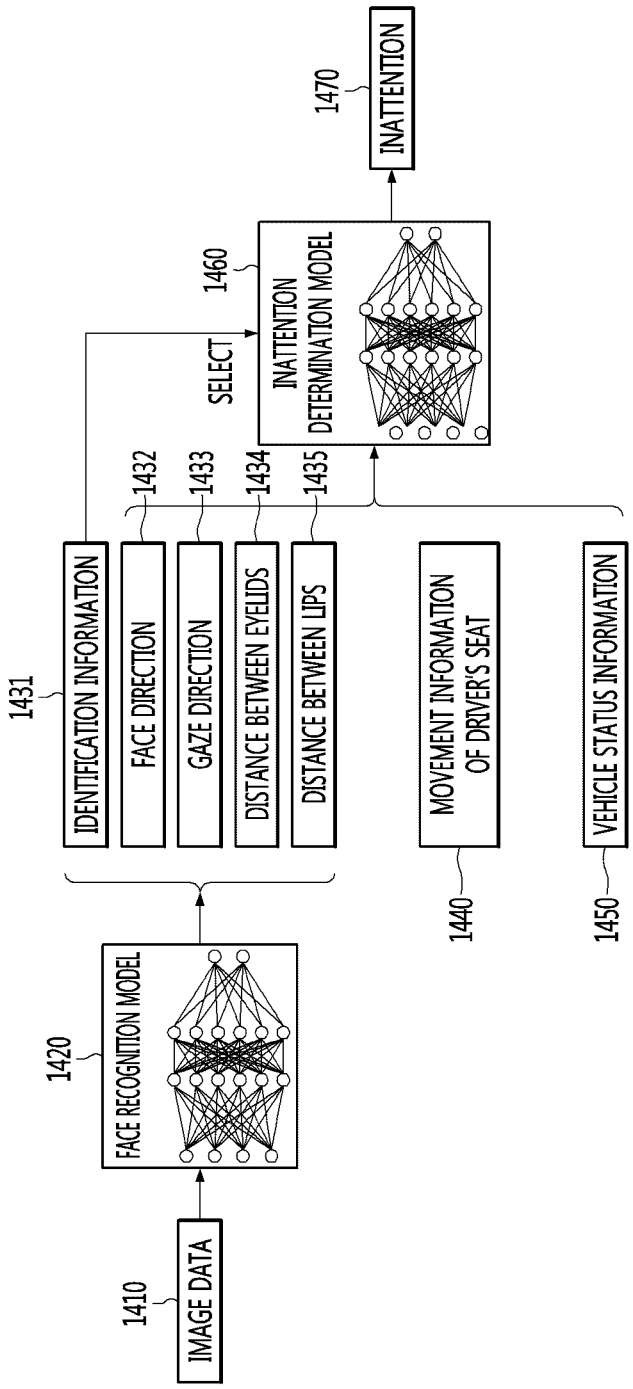
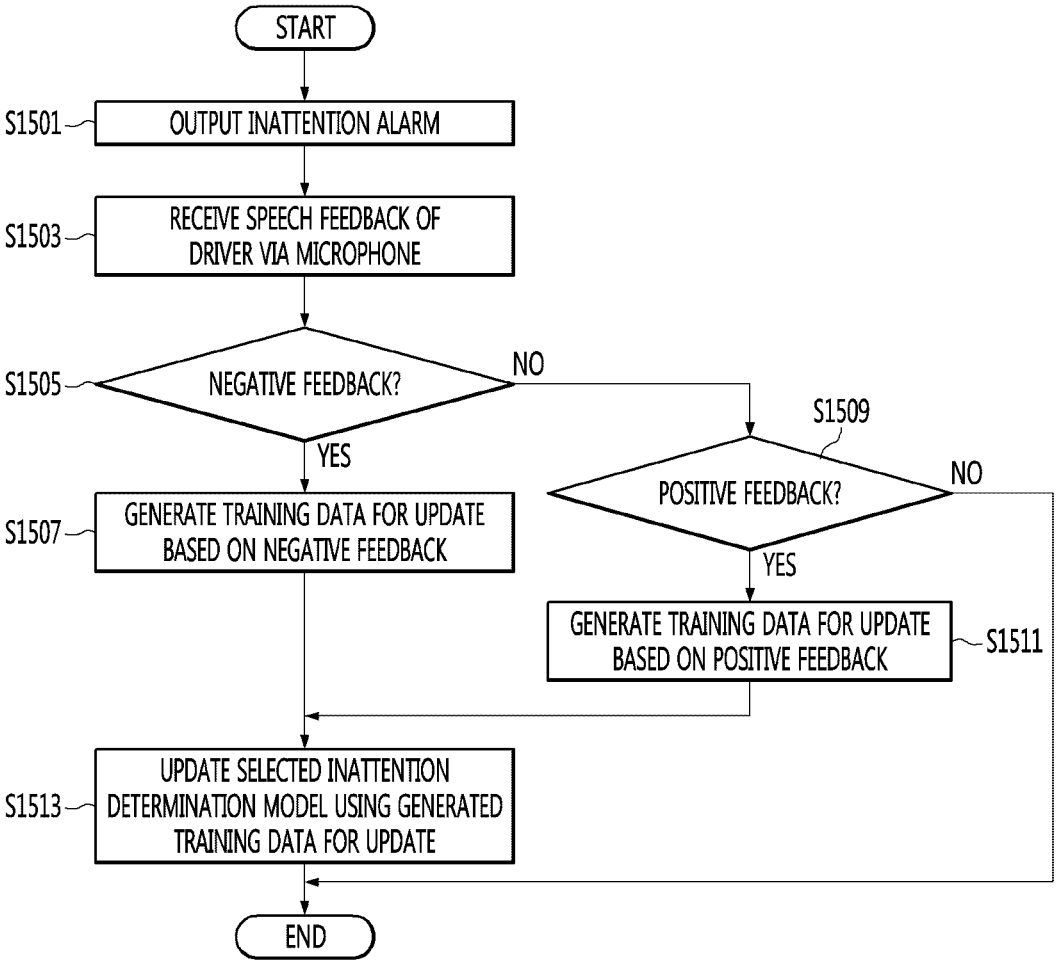

1410
IMAGE DATA
1420
FACE RECOGNITION MODEL
1431
IDENTIFICATION INFORMATION
FACE DIRECTION
GAZE DIRECTION
DISTANCE BETWEEN EYELIDS
DISTANCE BETWEEN LIPS
1432
1433
1434
1435
1440
MOVEMENT INFORMATION OF DRIVER'S SEAT
1450
VEHICLE STATUS INFORMATION
SELECT
1460
INATTENTION DETERMINATION MODEL
1470
INATTENTION

FIG. 15


START
S1501
OUTPUT INATTENTION ALARM
S1503
RECEIVE SPEECH FEEDBACK OF DRIVER VIA MICROPHONE
S1505
NEGATIVE FEEDBACK?
NO
YES
S1509
POSITIVE FEEDBACK?
NO
YES
S1507
GENERATE TRAINING DATA FOR UPDATE BASED ON NEGATIVE FEEDBACK
GENERATE TRAINING DATA FOR UPDATE BASED ON POSITIVE FEEDBACK
S1511
S1513
UPDATE SELECTED INATTENTION DETERMINATION MODEL USING GENERATED TRAINING DATA FOR UPDATE
END

ARTIFICIAL INTELLIGENCE APPARATUS AND METHOD FOR DETERMINING INATTENTION OF DRIVER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to Korean Patent Application No. 10-2019-0135577 filed in the Republic of Korea on Oct. 29, 2019, the entire contents of which are hereby incorporated by reference in its entirety.

BACKGROUND

The present disclosure relates to an artificial intelligence (AI) apparatus and method for determining intention of a driver.

Recently, technology for providing a vehicle with a driving assistance function for assisting operation for driving of a driver or an automatic driving function for replacing operation for driving of a driver has been actively developed. The driving assistance function (or a driving assistance system) may include a cruise control function, a vehicle clearance adjustment function, a lane maintenance function, a driver status monitoring (DSM) function, etc. In addition, the automatic driving function may be regarded as including all driving assistance functions.

The DSM function means a function for monitoring the status of a driver, such as driver's fatigue, drowsiness or careless behavior while driving the vehicle and detect a high risk situation to provide an alarm or provide a necessary response, and contributes to reducing the direct cause of an accident, such as driving while drowsy. However, even if a driver focuses on driving, the DSM function may be likely to incorrectly determine inattention of the driver. When a wrong alarm is provided, driver's satisfaction may be lowered. Accordingly, it is important to accurately determine inattention of the driver when monitoring the status of the driver.

SUMMARY

An object of the present disclosure is to provide an artificial intelligence apparatus and a method for determining inattention of a driver and providing an inattention alarm upon determining that the driver is in an inattention status.

Another object of the present disclosure is to provide an artificial intelligence apparatus and a method for determining an inattention status by applying different criteria according to drivers.

Another object of the present disclosure is to provide an artificial intelligence apparatus and a method for determining the inattention status of a driver based on feedback of the driver upon determining that the driver is in the inattention status.

According to an embodiment, provided are an artificial intelligence apparatus and a method for generating movement information of a driver's seat of a vehicle, receiving vehicle status information, generating driver status information using image data including a face of a driver, determining whether the driver is in an inattention status based on the movement information of the driver's seat, the driver status information and the vehicle status information, and outputting an inattention alarm if the driver is in the inattention status.

According to an embodiment, provided are an artificial intelligence apparatus and a method for identifying a type of a vehicle and a driver, determining an inattention determination profile or an inattention determination model to be used to determine inattention of the driver using the identified information, and determining inattention of the driver using the determined inattention determination profile and the determined inattention determination model.

According to an embodiment, provided are an artificial intelligence apparatus and a method for updating a reference value or an inattention determination model used to determine inattention of a driver in consideration of feedback of the driver after an inattention alarm is provided.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure will become more fully understood from the detailed description given herein below and the accompanying drawings, which are given by illustration only, and thus are not limitative of the present disclosure, and wherein:

FIG. **1** is a block diagram illustrating an AI apparatus according to an embodiment of the present disclosure.

FIG. **2** is a block diagram illustrating an AI server according to an embodiment of the present disclosure.

FIG. **3** is a view illustrating an AI system according to an embodiment of the present disclosure.

FIG. **4** is a block diagram illustrating an AI apparatus according to an embodiment of the present disclosure.

FIG. **5** is a flowchart illustrating a method of determining inattention of a driver according to an embodiment of the present disclosure.

FIG. **6** is a view illustrating a method of generating face recognition information according to an embodiment of the present disclosure.

FIG. **7** is a flowchart illustrating an example of step S**511** of determining inattention of a driver illustrated in FIG. **5**.

FIGS. **8** and **9** are views illustrating examples of a second reference range and a third reference range according to an embodiment of the present disclosure.

FIG. **10** is a view illustrating a relationship between a steering angle and direction boundary value coefficients according to an embodiment of the present disclosure.

FIG. **11** is a view illustrating a method of updating a third reference range according to an embodiment of the present disclosure.

FIG. **12** is a view illustrating a relationship between an updated steering angle and a directional boundary value coefficients based on negative feedback according to an embodiment of the present disclosure.

FIG. **13** is a flowchart illustrating an example of step S**511** of determining inattention of the driver shown in FIG. **5**.

FIG. **14** is a view illustrating a method of determining inattention of a driver according to an embodiment of the present disclosure.

FIG. **15** is a view illustrating a method of updating an inattention determination model according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Hereinafter, embodiments of the present disclosure are described in more detail with reference to accompanying drawings and regardless of the drawings symbols, same or similar components are assigned with the same reference numerals and thus overlapping descriptions for those are omitted. The suffixes "module" and "unit" for components used in the description below are assigned or mixed in

consideration of easiness in writing the specification and do not have distinctive meanings or roles by themselves. In the following description, detailed descriptions of well-known functions or constructions will be omitted since they would obscure the disclosure in unnecessary detail. Additionally, the accompanying drawings are used to help easily understanding embodiments disclosed herein but the technical idea of the present disclosure is not limited thereto. It should be understood that all of variations, equivalents or substitutes contained in the concept and technical scope of the present disclosure are also included.

It will be understood that the terms "first" and "second" are used herein to describe various components but these components should not be limited by these terms. These terms are used only to distinguish one component from other components.

In this disclosure below, when one part (or element, device, etc.) is referred to as being 'connected' to another part (or element, device, etc.), it should be understood that the former can be 'directly connected' to the latter, or 'electrically connected' to the latter via an intervening part (or element, device, etc.). It will be further understood that when one component is referred to as being 'directly connected' or 'directly linked' to another component, it means that no intervening component is present.

<Artificial Intelligence (AI)>

Artificial intelligence refers to the field of studying artificial intelligence or methodology for making artificial intelligence, and machine learning refers to the field of defining various issues dealt with in the field of artificial intelligence and studying methodology for solving the various issues. Machine learning is defined as an algorithm that enhances the performance of a certain task through a steady experience with the certain task.

An artificial neural network (ANN) is a model used in machine learning and may mean a whole model of problem-solving ability which is composed of artificial neurons (nodes) that form a network by synaptic connections. The artificial neural network can be defined by a connection pattern between neurons in different layers, a learning process for updating model parameters, and an activation function for generating an output value.

The artificial neural network may include an input layer, an output layer, and optionally one or more hidden layers. Each layer includes one or more neurons, and the artificial neural network may include a synapse that links neurons to neurons. In the artificial neural network, each neuron may output the function value of the activation function for input signals, weights, and deflections input through the synapse.

Model parameters refer to parameters determined through learning and include a weight value of synaptic connection and deflection of neurons. A hyperparameter means a parameter to be set in the machine learning algorithm before learning, and includes a learning rate, a repetition number, a mini batch size, and an initialization function.

The purpose of the learning of the artificial neural network may be to determine the model parameters that minimize a loss function. The loss function may be used as an index to determine optimal model parameters in the learning process of the artificial neural network.

Machine learning may be classified into supervised learning, unsupervised learning, and reinforcement learning according to a learning method.

The supervised learning may refer to a method of learning an artificial neural network in a state in which a label for training data is given, and the label may mean the correct answer (or result value) that the artificial neural network must infer when the training data is input to the artificial neural network. The unsupervised learning may refer to a method of learning an artificial neural network in a state in which a label for training data is not given. The reinforcement learning may refer to a learning method in which an agent defined in a certain environment learns to select a behavior or a behavior sequence that maximizes cumulative compensation in each state.

Machine learning, which is implemented as a deep neural network (DNN) including a plurality of hidden layers among artificial neural networks, is also referred to as deep learning, and the deep learning is part of machine learning. In the following, machine learning is used to mean deep learning.

<Robot>

A robot may refer to a machine that automatically processes or operates a given task by its own ability. In particular, a robot having a function of recognizing an environment and performing a self-determination operation may be referred to as an intelligent robot.

Robots may be classified into industrial robots, medical robots, home robots, military robots, and the like according to the use purpose or field.

The robot includes a driving unit may include an actuator or a motor and may perform various physical operations such as moving a robot joint. In addition, a movable robot may include a wheel, a brake, a propeller, and the like in a driving unit, and may travel on the ground through the driving unit or fly in the air.

<Self-Driving>

Self-driving refers to a technique of driving for oneself, and a self-driving vehicle refers to a vehicle that travels without an operation of a user or with a minimum operation of a user.

For example, the self-driving may include a technology for maintaining a lane while driving, a technology for automatically adjusting a speed, such as adaptive cruise control, a technique for automatically traveling along a predetermined route, and a technology for automatically setting and traveling a route when a destination is set.

The vehicle may include a vehicle having only an internal combustion engine, a hybrid vehicle having an internal combustion engine and an electric motor together, and an electric vehicle having only an electric motor, and may include not only an automobile but also a train, a motorcycle, and the like.

Here, the self-driving vehicle may be regarded as a robot having a self-driving function.

<EXtended Reality (XR)>

Extended reality is collectively referred to as virtual reality (VR), augmented reality (AR), and mixed reality (MR). The VR technology provides a real-world object and background only as a CG image, the AR technology provides a virtual CG image on a real object image, and the MR technology is a computer graphic technology that mixes and combines virtual objects into the real world.

The MR technology is similar to the AR technology in that the real object and the virtual object are shown together. However, in the AR technology, the virtual object is used in the form that complements the real object, whereas in the MR technology, the virtual object and the real object are used in an equal manner.

The XR technology may be applied to a head-mount display (HMD), a head-up display (HUD), a mobile phone, a tablet PC, laptop, a desktop, a TV, a digital signage, and the like. A device to which the XR technology is applied may be referred to as an XR device.

FIG. **1** is a block diagram illustrating an AI apparatus **100** according to an embodiment of the present disclosure.

Hereinafter, the AI apparatus **100** may be referred to as a terminal.

The AI apparatus (or an AI device) **100** may be implemented by a stationary device or a mobile device, such as a TV, a projector, a mobile phone, a smartphone, a desktop computer, a notebook, a digital broadcasting terminal, a personal digital assistant (PDA), a portable multimedia player (PMP), a navigation device, a tablet PC, a wearable device, a set-top box (STB), a DMB receiver, a radio, a washing machine, a refrigerator, a desktop computer, a digital signage, a robot, a vehicle, and the like.

Referring to FIG. **1**, the AI apparatus **100** may include a communication unit **110**, an input unit **120**, a learning processor **130**, a sensing unit **140**, an output unit **150**, a memory **170**, and a processor **180**.

The communication unit **110** may transmit and receive data to and from external devices such as other AI apparatuses **100***a* to **100***e* and the AI server **200** by using wire/wireless communication technology. For example, the communication unit **110** may transmit and receive sensor information, a user input, a learning model, and a control signal to and from external devices.

The communication technology used by the communication unit **110** includes GSM (Global System for Mobile communication), CDMA (Code Division Multi Access), LTE (Long Term Evolution), 5G, WLAN (Wireless LAN), Wi-Fi (Wireless-Fidelity), Bluetooth™, RFID (Radio Frequency Identification), Infrared Data Association (IrDA), ZigBee, NFC (Near Field Communication), and the like.

The input unit **120** may acquire various kinds of data.

Here, the input unit **120** may include a camera for inputting a video signal, a microphone for receiving an audio signal, and a user input unit for receiving information from a user. The camera or the microphone may be treated as a sensor, and the signal acquired from the camera or the microphone may be referred to as sensing data or sensor information.

The input unit **120** may acquire a training data for model learning and an input data to be used when an output is acquired by using learning model. The input unit **120** may acquire raw input data. Here, the processor **180** or the learning processor **130** may extract an input feature by preprocessing the input data.

The learning processor **130** may learn a model composed of an artificial neural network by using training data. The learned artificial neural network may be referred to as a learning model. The learning model may be used to an infer result value for new input data rather than training data, and the inferred value may be used as a basis for determination to perform a certain operation.

Here, the learning processor **130** may perform AI processing together with the learning processor **240** of the AI server **200**.

Here, the learning processor **130** may include a memory integrated or implemented in the AI apparatus **100**. Alternatively, the learning processor **130** may be implemented by using the memory **170**, an external memory directly connected to the AI apparatus **100**, or a memory held in an external device.

The sensing unit **140** may acquire at least one of internal information about the AI apparatus **100**, ambient environment information about the AI apparatus **100**, and user information by using various sensors.

Examples of the sensors included in the sensing unit **140** may include a proximity sensor, an illuminance sensor, an acceleration sensor, a magnetic sensor, a gyro sensor, an inertial sensor, an RGB sensor, an IR sensor, a fingerprint recognition sensor, an ultrasonic sensor, an optical sensor, a microphone, a lidar, and a radar.

The output unit **150** may generate an output related to a visual sense, an auditory sense, or a haptic sense.

Here, the output unit **150** may include a display unit for outputting time information, a speaker for outputting auditory information, and a haptic module for outputting haptic information.

The memory **170** may store data that supports various functions of the AI apparatus **100**. For example, the memory **170** may store input data acquired by the input unit **120**, training data, a learning model, a learning history, and the like.

The processor **180** may determine at least one executable operation of the AI apparatus **100** based on information determined or generated by using a data analysis algorithm or a machine learning algorithm. The processor **180** may control the components of the AI apparatus **100** to execute the determined operation.

To this end, the processor **180** may request, search, receive, or utilize data of the learning processor **130** or the memory **170**. The processor **180** may control the components of the AI apparatus **100** to execute the predicted operation or the operation determined to be desirable among the at least one executable operation.

When the connection of an external device is required to perform the determined operation, the processor **180** may generate a control signal for controlling the external device and may transmit the generated control signal to the external device.

The processor **180** may acquire intention information for the user input and may determine the user's requirements based on the acquired intention information.

The processor **180** may acquire the intention information corresponding to the user input by using at least one of a speech to text (STT) engine for converting speech input into a text string or a natural language processing (NLP) engine for acquiring intention information of a natural language.

At least one of the STT engine or the NLP engine may be configured as an artificial neural network, at least part of which is learned according to the machine learning algorithm. At least one of the STT engine or the NLP engine may be learned by the learning processor **130**, may be learned by the learning processor **240** of the AI server **200**, or may be learned by their distributed processing.

The processor **180** may collect history information including the operation contents of the AI apparatus **100** or the user's feedback on the operation and may store the collected history information in the memory **170** or the learning processor **130** or transmit the collected history information to the external device such as the AI server **200**. The collected history information may be used to update the learning model.

The processor **180** may control at least part of the components of AI apparatus **100** so as to drive an application program stored in memory **170**. Furthermore, the processor **180** may operate two or more of the components included in the AI apparatus **100** in combination so as to drive the application program.

FIG. **2** is a block diagram illustrating an AI server **200** according to an embodiment of the present disclosure.

Referring to FIG. **2**, the AI server **200** may refer to a device that learns an artificial neural network by using a machine learning algorithm or uses a learned artificial neural network. The AI server **200** may include a plurality of

servers to perform distributed processing, or may be defined as a 5G network. Here, the AI server **200** may be included as a partial configuration of the AI apparatus **100**, and may perform at least part of the AI processing together.

The AI server **200** may include a communication unit **210**, a memory **230**, a learning processor **240**, a processor **260**, and the like.

The communication unit **210** can transmit and receive data to and from an external device such as the AI apparatus **100**.

The memory **230** may include a model storage unit **231**. The model storage unit **231** may store a learning or learned model (or an artificial neural network **231***a*) through the learning processor **240**.

The learning processor **240** may learn the artificial neural network **231***a* by using the training data. The learning model may be used in a state of being mounted on the AI server **200** of the artificial neural network, or may be used in a state of being mounted on an external device such as the AI apparatus **100**.

The learning model may be implemented in hardware, software, or a combination of hardware and software. If all or part of the learning models are implemented in software, one or more instructions that constitute the learning model may be stored in memory **230**.

The processor **260** may infer the result value for new input data by using the learning model and may generate a response or a control command based on the inferred result value.

FIG. **3** is a view illustrating an AI system **1** according to an embodiment of the present disclosure.

Referring to FIG. **3**, in the AI system **1**, at least one of an AI server **200**, a robot **100***a*, a self-driving vehicle **100***b*, an XR device **100***c*, a smartphone **100***d*, or a home appliance **100***e* is connected to a cloud network **10**. The robot **100***a*, the self-driving vehicle **100***b*, the XR device **100***c*, the smartphone **100***d*, or the home appliance **100***e*, to which the AI technology is applied, may be referred to as AI apparatuses **100***a* to **100***e*.

The cloud network **10** may refer to a network that forms part of a cloud computing infrastructure or exists in a cloud computing infrastructure. The cloud network **10** may be configured by using a 3G network, a 4G or LTE network, or a 5G network.

That is, the devices **100***a* to **100***e* and **200** configuring the AI system **1** may be connected to each other through the cloud network **10**. In particular, each of the devices **100***a* to **100***e* and **200** may communicate with each other through a base station, but may directly communicate with each other without using a base station.

The AI server **200** may include a server that performs AI processing and a server that performs operations on big data.

The AI server **200** may be connected to at least one of the AI apparatuses constituting the AI system **1**, that is, the robot **100***a*, the self-driving vehicle **100***b*, the XR device **100***c*, the smartphone **100***d*, or the home appliance **100***e* through the cloud network **10**, and may assist at least part of AI processing of the connected AI apparatuses **100***a* to **100***e*.

Here, the AI server **200** may learn the artificial neural network according to the machine learning algorithm instead of the AI apparatuses **100***a* to **100***e*, and may directly store the learning model or transmit the learning model to the AI apparatuses **100***a* to **100***e*.

Here, the AI server **200** may receive input data from the AI apparatuses **100***a* to **100***e*, may infer the result value for the received input data by using the learning model, may generate a response or a control command based on the inferred result value, and may transmit the response or the control command to the AI apparatuses **100***a* to **100***e*.

Alternatively, the AI apparatuses **100***a* to **100***e* may infer the result value for the input data by directly using the learning model, and may generate the response or the control command based on the inference result.

Hereinafter, various embodiments of the AI apparatuses **100***a* to **100***e* to which the above-described technology is applied will be described. The AI apparatuses **100***a* to **100***e* illustrated in FIG. **3** may be regarded as a specific embodiment of the AI apparatus **100** illustrated in FIG. **1**.

<AI+Robot>

The robot **100***a*, to which the AI technology is applied, may be implemented as a guide robot, a carrying robot, a cleaning robot, a wearable robot, an entertainment robot, a pet robot, an unmanned flying robot, or the like.

The robot **100***a* may include a robot control module for controlling the operation, and the robot control module may refer to a software module or a chip implementing the software module by hardware.

The robot **100***a* may acquire state information about the robot **100***a* by using sensor information acquired from various kinds of sensors, may detect (recognize) surrounding environment and objects, may generate map data, may determine the route and the travel plan, may determine the response to user interaction, or may determine the operation.

The robot **100***a* may use the sensor information acquired from at least one sensor among the lidar, the radar, and the camera so as to determine the travel route and the travel plan.

The robot **100***a* may perform the above-described operations by using the learning model composed of at least one artificial neural network. For example, the robot **100***a* may recognize the surrounding environment and the objects by using the learning model, and may determine the operation by using the recognized surrounding information or object information. The learning model may be learned directly from the robot **100***a* or may be learned from an external device such as the AI server **200**.

Here, the robot **100***a* may perform the operation by generating the result by directly using the learning model, but the sensor information may be transmitted to the external device such as the AI server **200** and the generated result may be received to perform the operation.

The robot **100***a* may use at least one of the map data, the object information detected from the sensor information, or the object information acquired from the external device to determine the travel route and the travel plan, and may control the driving unit such that the robot **100***a* travels along the determined travel route and travel plan.

The map data may include object identification information about various objects arranged in the space in which the robot **100***a* moves. For example, the map data may include object identification information about fixed objects such as walls and doors and movable objects such as pollen and desks. The object identification information may include a name, a type, a distance, and a position.

In addition, the robot **100***a* may perform the operation or travel by controlling the driving unit based on the control/interaction of the user. Here, the robot **100***a* may acquire the intention information of the interaction due to the user's operation or speech utterance, and may determine the response based on the acquired intention information, and may perform the operation.

<AI+Self-Driving>

The self-driving vehicle **100***b*, to which the AI technology is applied, may be implemented as a mobile robot, a vehicle, an unmanned flying vehicle, or the like.

The self-driving vehicle **100***b* may include a self-driving control module for controlling a self-driving function, and the self-driving control module may refer to a software module or a chip implementing the software module by hardware. The self-driving control module may be included in the self-driving vehicle **100***b* as a component thereof, but may be implemented with separate hardware and connected to the outside of the self-driving vehicle **100***b*.

The self-driving vehicle **100***b* may acquire state information about the self-driving vehicle **100***b* by using sensor information acquired from various kinds of sensors, may detect (recognize) surrounding environment and objects, may generate map data, may determine the route and the travel plan, or may determine the operation.

Like the robot **100***a*, the self-driving vehicle **100***b* may use the sensor information acquired from at least one sensor among the lidar, the radar, and the camera so as to determine the travel route and the travel plan.

In particular, the self-driving vehicle **100***b* may recognize the environment or objects for an area covered by a field of view or an area over a certain distance by receiving the sensor information from external devices, or may receive directly recognized information from the external devices.

The self-driving vehicle **100***b* may perform the above-described operations by using the learning model composed of at least one artificial neural network. For example, the self-driving vehicle **100***b* may recognize the surrounding environment and the objects by using the learning model, and may determine the traveling route by using the recognized surrounding information or object information. The learning model may be learned directly from the self-driving vehicle **100***a* or may be learned from an external device such as the AI server **200**.

Here, the self-driving vehicle **100***b* may perform the operation by generating the result by directly using the learning model, but the sensor information may be transmitted to the external device such as the AI server **200** and the generated result may be received to perform the operation.

The self-driving vehicle **100***b* may use at least one of the map data, the object information detected from the sensor information, or the object information acquired from the external device to determine the travel route and the travel plan, and may control the driving unit such that the self-driving vehicle **100***b* travels along the determined travel route and travel plan.

The map data may include object identification information about various objects arranged in the space (for example, road) in which the self-driving vehicle **100***b* travels. For example, the map data may include object identification information about fixed objects such as street lamps, rocks, and buildings and movable objects such as vehicles and pedestrians. The object identification information may include a name, a type, a distance, and a position.

In addition, the self-driving vehicle **100***b* may perform the operation or travel by controlling the driving unit based on the control/interaction of the user. Here, the self-driving vehicle **100***b* may acquire the intention information of the interaction due to the user's operation or speech utterance, and may determine the response based on the acquired intention information, and may perform the operation.

<AI+XR>

The XR device **100***c*, to which the AI technology is applied, may be implemented by a head-mount display (HMD), a head-up display (HUD) provided in the vehicle, a television, a mobile phone, a smartphone, a computer, a wearable device, a home appliance, a digital signage, a vehicle, a fixed robot, a mobile robot, or the like.

The XR device **100***c* may analyzes three-dimensional point cloud data or image data acquired from various sensors or the external devices, generate position data and attribute data for the three-dimensional points, acquire information about the surrounding space or the real object, and render to output the XR object to be output. For example, the XR device **100***c* may output an XR object including the additional information about the recognized object in correspondence to the recognized object.

The XR device **100***c* may perform the above-described operations by using the learning model composed of at least one artificial neural network. For example, the XR device **100***c* may recognize the real object from the three-dimensional point cloud data or the image data by using the learning model, and may provide information corresponding to the recognized real object. The learning model may be directly learned from the XR device **100***c*, or may be learned from the external device such as the AI server **200**.

Here, the XR device **100***c* may perform the operation by generating the result by directly using the learning model, but the sensor information may be transmitted to the external device such as the AI server **200** and the generated result may be received to perform the operation.

<AI+Robot+Self-Driving>

The robot **100***a*, to which the AI technology and the self-driving technology are applied, may be implemented as a guide robot, a carrying robot, a cleaning robot, a wearable robot, an entertainment robot, a pet robot, an unmanned flying robot, or the like.

The robot **100***a*, to which the AI technology and the self-driving technology are applied, may refer to the robot itself having the self-driving function or the robot **100***a* interacting with the self-driving vehicle **100***b*.

The robot **100***a* having the self-driving function may collectively refer to a device that moves for itself along the given route without the user's control or moves for itself by determining the route by itself.

The robot **100***a* and the self-driving vehicle **100***b* having the self-driving function may use a common sensing method so as to determine at least one of the travel route or the travel plan. For example, the robot **100***a* and the self-driving vehicle **100***b* having the self-driving function may determine at least one of the travel route or the travel plan by using the information sensed through the lidar, the radar, and the camera.

The robot **100***a* that interacts with the self-driving vehicle **100***b* exists separately from the self-driving vehicle **100***b* and may perform operations interworking with the self-driving function of the self-driving vehicle **100***b* or interworking with the user who rides on the self-driving vehicle **100***b*.

Here, the robot **100***a* interacting with the self-driving vehicle **100***b* may control or assist the self-driving function of the self-driving vehicle **100***b* by acquiring sensor information on behalf of the self-driving vehicle **100***b* and providing the sensor information to the self-driving vehicle **100***b*, or by acquiring sensor information, generating environment information or object information, and providing the information to the self-driving vehicle **100***b*.

Alternatively, the robot **100***a* interacting with the self-driving vehicle **100***b* may monitor the user boarding the

self-driving vehicle **100***b*, or may control the function of the self-driving vehicle **100***b* through the interaction with the user. For example, when it is determined that the driver is in a drowsy state, the robot **100***a* may activate the self-driving function of the self-driving vehicle **100***b* or assist the control of the driving unit of the self-driving vehicle **100***b*. The function of the self-driving vehicle **100***b* controlled by the robot **100***a* may include not only the self-driving function but also the function provided by the navigation system or the audio system provided in the self-driving vehicle **100***b*.

Alternatively, the robot **100***a* that interacts with the self-driving vehicle **100***b* may provide information or assist the function to the self-driving vehicle **100***b* outside the self-driving vehicle **100***b*. For example, the robot **100***a* may provide traffic information including signal information and the like, such as a smart signal, to the self-driving vehicle **100***b*, and automatically connect an electric charger to a charging port by interacting with the self-driving vehicle **100***b* like an automatic electric charger of an electric vehicle.

<AI+Robot+XR>

The robot **100***a*, to which the AI technology and the XR technology are applied, may be implemented as a guide robot, a carrying robot, a cleaning robot, a wearable robot, an entertainment robot, a pet robot, an unmanned flying robot, a drone, or the like.

The robot **100***a*, to which the XR technology is applied, may refer to a robot that is subjected to control/interaction in an XR image. In this case, the robot **100***a* may be separated from the XR device **100***c* and interwork with each other.

When the robot **100***a*, which is subjected to control/interaction in the XR image, may acquire the sensor information from the sensors including the camera, the robot **100***a* or the XR device **100***c* may generate the XR image based on the sensor information, and the XR device **100***c* may output the generated XR image. The robot **100***a* may operate based on the control signal input through the XR device **100***c* or the user's interaction.

For example, the user can confirm the XR image corresponding to the time point of the robot **100***a* interworking remotely through the external device such as the XR device **100***c*, adjust the self-driving travel path of the robot **100***a* through interaction, control the operation or driving, or confirm the information about the surrounding object.

<AI+Self-Driving+XR>

The self-driving vehicle **100***b*, to which the AI technology and the XR technology are applied, may be implemented as a mobile robot, a vehicle, an unmanned flying vehicle, or the like.

The self-driving driving vehicle **100***b*, to which the XR technology is applied, may refer to a self-driving vehicle having a means for providing an XR image or a self-driving vehicle that is subjected to control/interaction in an XR image. Particularly, the self-driving vehicle **100***b* that is subjected to control/interaction in the XR image may be distinguished from the XR device **100***c* and interwork with each other.

The self-driving vehicle **100***b* having the means for providing the XR image may acquire the sensor information from the sensors including the camera and output the generated XR image based on the acquired sensor information. For example, the self-driving vehicle **100***b* may include an HUD to output an XR image, thereby providing a passenger with a real object or an XR object corresponding to an object in the screen.

Here, when the XR object is output to the HUD, at least part of the XR object may be outputted so as to overlap the actual object to which the passenger's gaze is directed. Meanwhile, when the XR object is output to the display provided in the self-driving vehicle **100***b*, at least part of the XR object may be output so as to overlap the object in the screen. For example, the self-driving vehicle **100***b* may output XR objects corresponding to objects such as a lane, another vehicle, a traffic light, a traffic sign, a two-wheeled vehicle, a pedestrian, a building, and the like.

When the self-driving vehicle **100***b*, which is subjected to control/interaction in the XR image, may acquire the sensor information from the sensors including the camera, the self-driving vehicle **100***b* or the XR device **100***c* may generate the XR image based on the sensor information, and the XR device **100***c* may output the generated XR image. The self-driving vehicle **100***b* may operate based on the control signal input through the external device such as the XR device **100***c* or the user's interaction.

FIG. **4** is a block diagram illustrating an AI apparatus **100** according to an embodiment of the present disclosure.

The redundant repeat of FIG. **1** will be omitted below.

The communication unit **110** may also be referred to as a communication modem or a communication circuit.

Referring to FIG. **4**, the input unit **120** may include a camera **121** for image signal input, a microphone **122** for receiving audio signal input, and a user input unit **123** for receiving information from a user.

Voice data or image data collected by the input unit **120** are analyzed and processed as a user's control command.

Then, the input unit **120** is used for inputting image information (or signal), audio information (or signal), data, or information inputted from a user and the AI apparatus **100** may include at least one camera **121** in order for inputting image information.

The camera **121** processes image frames such as a still image or a video obtained by an image sensor in a video call mode or a capturing mode. The processed image frame may be displayed on the display unit **151** or stored in the memory **170**.

The microphone **122** processes external sound signals as electrical voice data. The processed voice data may be utilized variously according to a function (or an application program being executed) being performed in the AI apparatus **100**. Moreover, various noise canceling algorithms for removing noise occurring during the reception of external sound signals may be implemented in the microphone **122**.

The user input unit **123** is to receive information from a user and when information is inputted through the user input unit **123**, the processor **180** may control an operation of the AI apparatus **100** to correspond to the inputted information.

The user input unit **123** may include a mechanical input means (or a mechanical key, for example, a button, a dome switch, a jog wheel, and a jog switch at the front, back or side of the AI apparatus **100**) and a touch type input means. As one example, a touch type input means may include a virtual key, a soft key, or a visual key, which is displayed on a touch screen through software processing or may include a touch key disposed at a portion other than the touch screen.

The sensing unit **140** may also be referred to as a sensor unit.

The output unit **150** may include at least one of a display unit **151**, a sound output module **152**, a haptic module **153**, or an optical output module **154**.

The display unit **151** may display (output) information processed in the AI apparatus **100**. For example, the display unit **151** may display execution screen information of an application program running on the AI apparatus **100** or user

interface (UI) and graphic user interface (GUI) information according to such execution screen information.

The display unit **151** may be formed with a mutual layer structure with a touch sensor or formed integrally, so that a touch screen may be implemented. Such a touch screen may serve as the user input unit **123** providing an input interface between the AI apparatus **100** and a user, and an output interface between the AI apparatus **100** and a user at the same time.

The sound output module **152** may output audio data received from the wireless communication unit **110** or stored in the memory **170** in a call signal reception or call mode, a recording mode, a voice recognition mode, or a broadcast reception mode.

The sound output module **152** may include a receiver, a speaker, and a buzzer.

The haptic module **153** generates various haptic effects that a user can feel. A representative example of a haptic effect that the haptic module **153** generates is vibration.

The optical output module **154** outputs a signal for notifying event occurrence by using light of a light source of the AI apparatus **100**. An example of an event occurring in the AI apparatus **100** includes message reception, call signal reception, missed calls, alarm, schedule notification, e-mail reception, and information reception through an application.

FIG. **5** is a flowchart illustrating a method of determining inattention of a driver according to an embodiment of the present disclosure.

The method of determining inattention of the driver may be performed by the artificial intelligence apparatus **100**. The artificial intelligence apparatus **100** may be mounted in a vehicle or may be a vehicle itself. In one embodiment, the artificial intelligence apparatus **100** may mean an apparatus for driving a driver status monitoring (DSM) system.

In the present disclosure, the vehicle means a means of transportation which moves as reaction to friction between wheels and a road surface by artificial power, and includes sedans, sports utility vehicles (SUVs), trucks and buses. The present disclosure is not limited by the shape or type of the vehicle. However, since a driver's behavior for driving varies depending on the type of the vehicle, a method of determining inattention of the driver may vary.

The processor **180** of the artificial intelligence apparatus **100** may perform the method of determining inattention of the driver when the vehicle starts to travel, when the vehicle is traveling or when the vehicle is preparing to travel.

Referring to FIG. **5**, the processor **180** of the artificial intelligence apparatus **100** receives vibration sensor information or gyro sensor information (S**501**), and generates movement information of driver's seat (S**503**).

Typically, a vehicle such as a sedan or SUV is designed such that a driver's seat is fixed to a vehicle body and is moved along with the vehicle body. However, in a vehicle such as a truck or a bus, a driver's seat is connected to a vehicle body but may be further moved upward and downward independently of movement of the vehicle body. When the truck or the bus travels on a rough or curved road surface, the driver's seat may be moved upward and downward independently of the vehicle body. Therefore, even if the driver does not move, the position of the user in image data to be received via the camera **121** may vary.

The processor **180** may receive vibration sensor information or gyro sensor information via a vibration sensor or a gyro sensor provided in the driver's seat and generate movement information of the driver's seat using the received vibration sensor information or the received gyro sensor information.

The processor **180** may receive first vibration sensor information or first gyro sensor information via a first vibration sensor or a first gyro sensor provided in the driver's seat, receive second vibration sensor information or second gyro sensor information via a second vibration sensor or a second gyro sensor provided in a vehicle body (e.g., a dashboard, a ceiling, a rearview mirror, etc.), and obtain movement information of the driver's seat using the received first and second vibration sensor information or the received first and second gyro sensor information. In this case, the processor **180** may generate movement information of the driver's seat relative to movement of the vehicle body from a difference between the first vibration sensor information and the second vibration sensor information or the first gyro sensor information and the second gyro sensor information. In addition, the processor **180** may generate movement information of the vehicle body using the received second vibration sensor information or second gyro sensor information.

In addition, the processor **180** of the artificial intelligence apparatus **100** receives image data including the face of the driver via the camera **121** (S**505**).

The camera **121** may be installed in the vehicle in the front direction of the driver to receive the image data including the face of the user. For example, the camera **121** may be attached or fastened to the windshield, ceiling, dashboard or steering wheel of the vehicle. In some embodiments, the camera **121** may be additionally installed in the vehicle in the lateral direction of the driver to additionally receive image data including the side face of the user. That is, the camera **121** is not limited to a single camera.

The camera **121** may include at least one of an RGB camera, an IR camera or a depth camera. If the camera **121** includes an RGB camera, the received image data may include RGB image data. If the camera **121** includes an infrared camera, the received image data may include infrared image data. If the camera **121** includes a depth camera, the received image data may include depth image data.

In one embodiment, the processor **180** may correct the image data to compensate for movement of the driver's seat based on the obtained movement information of the driver's seat. For example, if the driver's seat is recognized as being moved upward from a basic state by 5 cm, the image data may be corrected by moving the image data downward by an amount (e.g., 1 cm) obtained by multiplying 5 cm by a predetermined ratio. By correcting the image data based on the movement information of the driver's seat, it is possible to minimize movement of an area, in which the face of the driver is located, in the image data.

In addition, the processor **180** of the artificial intelligence apparatus **100** recognizes the face of the driver from the received image data to generate driver status information (S**507**).

Recognizing the face of the driver may mean simply recognizing the face of a person or identifying the driver along with the face of the driver. To this end, the processor **180** may recognize the face of the user using a face recognition model to generate driver status information. The face recognition model may be an artificial neural network including a convolutional neural network (CNN) learned using a deep learning algorithm.

The driver status information may include at least one of the identification information of the driver, the face direction of the driver, the gaze direction of the driver, a degree to which the driver's eyes are closed (or a distance between eyelids), a degree to which the driver's mouth is open (or a distance between lips) or whether the driver is drowsing.

The identification information of the driver may be face shape based identification information generated by extracting feature points from the face of the driver or iris shape based identification information generated by extracting feature points from the iris of the driver's eye.

The face direction of the driver and the gaze direction of the driver may be expressed by an angle from the front surface of the vehicle in upward, downward, left and right directions. For example, when the face of the driver faces the front center of the vehicle, the face direction of the driver may be expressed by 0 degrees in an upward-and-downward direction and 0 degrees in a left-and-right direction. In addition, when the driver looks to the right, the left-and-right angle may be expressed by +n degrees and, when the driver looks upward, the upward-and-downward angle may be expressed by +m degrees. The method of expressing the angle representing each direction is merely an example and any expression method indicating the upward, downward, left and right directions may be used. The face direction of the driver may mean the head pose of the driver.

The degree to which the eyes of the driver are closed may be expressed by a numerical number of the distance between eyelids of each eye of the driver or may be expressed by a ratio a current distance between eyelids to a maximum value of the distance between the eyelids of the driver. For example, the degree to which the eyes of the driver are closed may be expressed as 6 mm for the left eye and 7 mm for the right eye. As the degree to which the eyes of the driver are closed, any expression method indicating the degree to which the eyes are closed may be used. In addition, the degree to which the eyes of the driver are closed may be expressed by the size of the recognized pupil of the driver. This is because the size of the recognized pupil decreases as the driver's eyes are closed.

The degree to which the driver's mouth is open may be expressed by the numerical value of the distance between the lips of the driver or a ratio of a current distance between the lips to a maximum value of the distance between the lips of the driver. For example, the degree to which the driver's mouth is open may be expressed as 35 mm. As the degree to which the driver's mouth is open, any expression method indicating how wide the mouth is open may be used.

Whether the driver is drowsing may be simply expressed by yes and no or may be expressed by a real number between 0 and 1 as a degree of drowsiness.

In one embodiment, the processor **180** may perform initialization or calibration for obtaining driver status information before starting driving, for example, at the time of starting. That is, in order to set a reference value for the front direction of the gaze direction of the driver or the face direction of the driver included in the driver status information, the driver may be guided or induced to look to the front, and the face direction or the gaze direction recognized from the image data received in a state in which the driver looks to the front may be set to the front direction.

In addition, the processor **180** of the artificial intelligence apparatus **100** receives vehicle status information from an electronic control unit (ECU) of the vehicle via the communication unit **110** (S**509**).

If the artificial intelligence apparatus **100** is configured to be separated from the vehicle, the artificial intelligence apparatus **100** may receive the vehicle status information from the ECU of the vehicle using wired/wireless communication such as a controller area network (CAN) via the communication unit **110**. In contrast, if the artificial intelligence apparatus **100** is configured as the vehicle itself, the processor **180** of the artificial intelligence apparatus **100** may receive the vehicle status information from the ECU. The signal received from the ECU may also be referred to as a CAN signal.

The ECU of the vehicle is a control unit for controlling an engine, a transmission, a brake, etc. of the vehicle and collects sensor information from various types of sensors mounted in the vehicle. For example, the sensor information collected by the ECU may include a vehicle speed, a revolutions per minute (RPM) of the engine, a transmission gear state, pedal pressure, a steering angle, a lighting state of a turn signal lamp, etc., and the collected sensor information may configure the vehicle status information.

In addition, the processor **180** of the artificial intelligence apparatus **100** determines inattention of the driver based on movement information of the driver's seat, the driver status information and the vehicle status information (S**511** and S**513**).

The method of determining inattention of the driver may include a rule-based determination method and a machine learning-based determination method.

The method of determining inattention of the driver will be described.

If the driver is in the inattention status as the result of determination of step S**513**, the processor **180** of the artificial intelligence apparatus **100** outputs an inattention alarm (S**515**).

The inattention alarm may include an alarm for notifying the driver of the inattention status or an alarm for calling the driver's attention.

The processor **180** may output a voice alarm, a beep alarm, a predetermined sound alarm, etc., which notifies the driver of inattention via the sound output module **152**. For example, the processor **180** may output, via the sound output module **152**, a voice alarm "You are currently in the inattention status. Please drive carefully", a warning alarm of a beep or a predetermined sound or music alarm as the inattention alarm.

The processor **180** may output, via the display unit **151**, an image alarm which notifies the driver of inattention. For example, the processor **180** may output, via a head-up display (HUD) of the vehicle, a text alarm "You are currently in the inattention status. Please drive carefully" as the inattention alarm. In particular, the processor **180** may output the inattention alarm on the window, to which the driver looks, via the HUD.

The processor **180** may generate vibration notifying the driver of inattention via the haptic module **153**. For example, the processor **180** may output the inattention alarm by driving a motor installed in a car seat upon determining that the driver is in the inattention status. For example, if the car seat of the vehicle provides a massage function, the processor **180** may output the inattention alarm, by performing at least a part of the massage function of the car seat upon determining that the driver is in the inattention status.

The processor **180** may output a lamp alarm notifying the driver of inattention via the optical output unit **154**. For example, the processor **180** may output an alarm indicating that the driver is currently in the inattention status, by turning on a warning lamp installed on the dashboard of the vehicle.

If the driver is not in the inattention status as the result of determination of step S**513** or if step S**515** is performed, the processor **180** of the artificial intelligence apparatus **100** determines whether traveling has ended (S**517**).

The processor **180** may determine whether traveling has ended, by determining whether the engine or the motor is in operation.

If traveling has not ended as the result of determination of step S517, the method returns to step S501.

If the vehicle is still traveling, necessary data and information are received again to determine the inattention of the driver.

If traveling has ended as the result of determination of step S517, the procedure for determining the inattention of the driver ends.

The processor **180** may determine whether traveling has ended based on the vehicle status information received from the ECU of the vehicle. For example, if gear information included in the vehicle status information is a parking gear or if the vehicle status information is not received from the ECU as the vehicle is turned off, the processor **180** may determine that traveling has ended.

FIG. **5** shows only one cycle of the method of determining the inattention of the driver according to one embodiment. The steps shown in FIG. **5** may be repeatedly performed and thus the artificial intelligence apparatus **100** may repeatedly determine the inattention of the driver.

The order of the steps shown in FIG. **5** is merely an example and the present disclosure is not limited thereto. That is, in one embodiment, the order of some of the steps shown in FIG. **5** may be reversed. In addition, in one embodiment, some of the steps shown in FIG. **5** may be performed in parallel.

FIG. **6** is a view illustrating a method of generating face recognition information according to an embodiment of the present disclosure.

Referring to FIG. **6**(*a*), the processor **180** may obtain image data **611** and **612** including the face of a driver **601** through a camera **121** installed inside a vehicle. For example, the processor **180** may obtain depth image data **611** using a depth camera, and may obtain RGB image data **612** using a typical RGB camera.

Referring to FIG. **9**(*b*), the processor **180** may extract features from the face of the driver **601** from depth image data **611** to recognize the face (**621**). The processor **180** may identify a plurality of drivers by distinguishing between the plurality of drivers, determine the head direction of the driver, or determine whether the user is opening the mouth of the user, through the face recognition.

Referring to FIG. **9**(*c*), the processor **180** may recognize the eyes of the driver **601** from the RGB image data **612** (**622**). The recognizing of the eyes (**622**) may include recognizing the gaze direction.

Referring to FIG. **9**(*d*), the processor **180** may recognize whether the driver **961** closes the eyes, or recognize eyelids of the driver from the RGB image data **612** (**623**). The recognizing of whether the driver closes the eyes (**623**) may be determined by measuring the distance between the eyelids, or by determining whether the eyeball is not recognized at the position of the eyeball.

As such, the processor **180** may distinguish the drivers from each other and determine whether the driver is yawning by recognizing the face of the driver **601**. Also, the processor **180** may determine whether the driver **601** gazes the side window, the side mirror or the room mirror by recognizing the eyeballs of the driver **601**. Also, the processor **180** may determine whether the driver **601** is drowsing by recognizing the eyelid of the driver **601**.

FIG. **7** is a flowchart illustrating an example of step S511 of determining inattention of a driver illustrated in FIG. **5**.

FIG. **7** shows an example of a method of determining the inattention of the driver using a rule-based inattention determination model among the methods of determining the inattention of the driver.

Referring to FIG. **7**, the processor **180** of the artificial intelligence apparatus **100** selects an inattention determination profile to be used to determine the inattention of the driver (S701).

The inattention determination profile may be a collection of reference values used to determine the inattention of the driver and may include a reference range or boundary values described below.

The inattention determination profile may be classified according to the type of the vehicle, and the base value of the reference range or boundary value included in the inattention determination profile may be set according to the type of the vehicle. For example, the base value of the reference range and the boundary value included in the inattention determination profile of a sedan may be different from that of the reference range and the boundary value included in the inattention determination profile of a truck. That is, the base value (or initial value) of the reference value to be used to determine the inattention of the driver may be determined based on the type of the vehicle.

In addition, the inattention determination profile may be classified according to the driver, and the reference range or boundary values included in the inattention determination profile may be set for each the driver. For example, the reference range and boundary value included in the inattention determination profile of a first driver may be different from the reference range and boundary value included in the inattention determination profile of a second driver. That is, the reference values to be used to determine the inattention of the driver may be differently determined according to the driver. This is because driving habits differ between drivers.

Accordingly, the processor **180** may select an inattention determination profile based on the type of the vehicle, in which the artificial intelligence apparatus **100** is installed, and a current driver. The current driver may be determined from driver identification information obtained from the received image data.

In addition, the processor **180** of the artificial intelligence apparatus **100** determines whether movement of the driver's seat is within a first reference range (S703).

The movement information of the driver's seat may include how much the driver's seat has moves upward and downward. If the vehicle travels on a bad road surface or a curved road, the driver's seat may move a lot. In addition, when the driver's seat moves a lot, the entire face of the driver may not be included in the image data received from the camera **121** or a lot of afterimages may be included, thereby failing to generating the driver status information or decreasing the accuracy of the generated driver status information. Movement of the driver's seat being within the first reference range may mean that movement of the driver's seat is not large. In contrast, the driver's seat being not within the first reference range may mean that movement of the driver's seat is large.

The first reference range may be a reference range included in the inattention determination profile selected in step S701. That is, the first reference range may mean a movement reference range of the driver's seat, and the first reference range used in step S703 is a movement reference range of the driver's seat selected in step S701. For example, the first reference range may be within 10 centimeters from a base state upward and downward.

If movement of the driver's seat is not within the first reference range as the result of determination of step S703, the processor **180** of the artificial intelligence apparatus **100** ends the procedure without determining the inattention of

the driver. That is, the procedure progresses to step S513 of determining whether the driver is in the inattention state.

If movement of the driver's seat is not within the first reference range, this may mean that the driver's seat has moved too much to determine the status of the driver and thus may be regarded as being inadequate to determine the inattention of the driver. Accordingly, in this case, the processor **180** may end step S511 of determining the inattention of the driver without determining the inattention of the driver. Since the inattention of the driver is not determined, this means that it is not determined that the driver is in the inattention status and thus the processor **180** may not provide the driver with the inattention alarm.

If the driver's seat has moved a lot, it can be expected that the driver does not drowse or the attention of the driver is not distracted, safety problems may be regarded as not occurring even if the inattention of the driver is not determined.

If the movement of the driver's seat is within the first reference range as the result of determination of step S703, the processor **180** of the artificial intelligence apparatus **100** determines whether the driver is in a drowsy status (S705).

The processor **180** may determine whether the driver is in a drowsy status or how close the user is to the drowsy status, in consideration of at least one of a degree to which the driver's eyes are closed (or the difference between the eyelids), the degree to which the mouth is open or the face direction (or the head direction) of the driver. For example, the processor **180** may recognize the yawn of the driver based on the degree to which the mouth is open, and recognize whether the driver's head nods based on the face direction of the driver. The processor **180** may determine whether the driver is in a drowsy status or how close the user is to the drowsy status, in consideration of how many the driver yawns, how narrow the distance between the eyelids is, or how many the driver's head nods.

If the processor **180** determines how close the driver is to the drowsy status, the score of drowsiness indicating how close to the drowsy status may be calculated and, if the calculated score of drowsiness exceeds a predetermined boundary value, it may be determined that the driver is in a drowsy status.

In addition, the processor **180** may determine a drowsy status using the reference values included in the inattention determination profile. For example, the processor **180** may compare the count of yawns of the driver with a yawn count reference value during a predetermined time (e.g., 5 minutes) using the yawn count reference value included in the inattention determination profile, and determine the drowsy status of the driver based on the result of comparison.

If the driver is in the drowsy status as the result of determination of step S705, the processor **180** of the artificial intelligence apparatus **100** determines that the driver is in the inattention status (S707).

If the driver is not in the drowsy status as the result of determination of step S705, the processor **180** of the artificial intelligence apparatus **100** determines whether a reverse gear is connected (S709).

The transmission gear state may include which gear is currently connected to the transmission. If the vehicle is connected to the reverse gear, the driver will want to check the side and the rear of the vehicle as well as the front of the vehicle, in order to move backward. Accordingly, the movement of the head or face and eyes of the driver in a state in which the reverse gear is connected may be greater than the movement of the head or face and eyes of the driver in the drive gear state.

If the reverse gear is connected as the result of determination of step S709, the processor **180** of the artificial intelligence apparatus **100** ends the procedure without determining the inattention of the driver. That is, the procedure progresses to step S513 of determining whether the driver is in the inattention status.

Alternatively, the processor **180** of the artificial intelligence apparatus **100** may determine that the driver is not in the inattention status.

If the reverse gear is not connected as the result of determination of step S709, the processor **180** of the artificial intelligence apparatus **100** determines whether the face direction of the driver or the gaze direction of the driver is within a second reference range (S711).

The second reference range is a basic determination range for presenting the face direction of the driver or the gaze direction of the driver when driving is normally performed. For example, the second reference range may be within 30 degrees in an upward-and-downward direction and within 60 degrees in a left-and-right direction. If the face direction or gaze direction of the driver is within the second reference range, the driver may be regarded as being not in the inattention status, regardless of whether the vehicle is going straight or turning.

If the face direction of the driver or the gaze direction of the driver is within the second reference range as the result of determination of step S711, the processor **180** of the artificial intelligence apparatus **100** determines that the driver is not in the inattention status (S713).

If the face direction of the driver or the gaze direction of the driver is not within the second reference range as the result of determination of step S711, the processor **180** of the artificial intelligence apparatus **100** determines a third reference range in consideration of a steering angle or a lighting state of a turn signal lamp (S715).

The third reference range is modified from the second reference range, in order to more accurately determine the inattention status of the driver in consideration that the field of vision of the driver widens in a state in which the vehicle is turning.

When a steering angle is large, the driver may frequently look in a direction corresponding to the steering angle. For example, in a situation in which the steering wheel has been turned clockwise in advance for a right turn or in a situation in which the steering wheel has been turned clockwise during a right turn, the driver may basically look to the right a lot for safety and additionally look to the left. Accordingly, the processor **180** may determine the third reference range obtained by modifying the second reference range in consideration of the steering angle, and the determined third reference range may be used as a criterion for determining the inattention status of the driver.

The turn signal lamp may be turned on in a situation in which turning is prepared as well as the case where the driver is turning, thereby representing the driver's intention to turn. Even if the driver turns on the turn signal lamp with the intention to turn, the steering wheel may not be immediately turned at that time. Since the driver turns on the turn signal lamp and look to the side for safety, even if the steering angle is not changed, it is necessary to determine whether the driver is in the inattention status in consideration of turning.

The processor **180** may determine the third reference range, by multiplying an upward-direction threshold value by an upward-direction threshold value coefficient, multiplying a downward-direction threshold value by a downward-direction threshold value coefficient, multiplying a left

threshold value by a left threshold value coefficient, and multiplying a right-direction threshold value by a right-direction threshold value coefficient in the second reference range, using the upward-direction threshold value coefficient, the downward-direction threshold value coefficient, the left-direction threshold value coefficient, and the right-direction threshold value coefficient included in the inattention determination profile.

Each direction threshold value coefficient may be dependent on the steering angle. For example, each direction threshold value coefficient when the steering angle is 10 degrees in the right direction may be different from each direction threshold value coefficient when the steering angle is 30 degrees in the right direction. For example, each direction threshold value coefficient may be expressed as an increasing function of the absolute value of the steering angle. In contrast, since the turn signal lamp is expressed by a discrete value unlike the steering angle, each direction threshold coefficient may be dependent on which turn signal lamp is turned on.

If the steering angle is 0 degrees and the turn signal lamp is not turned on, all the direction threshold value coefficients may be 1. This means that the third reference range is determined equally to the second reference range.

Since the inattention determination profile may be set for each vehicle and driver, each direction threshold value coefficient may be differently set according to driver and the third reference range may be differently set according to driver. In addition, the direction threshold value coefficients set according to driver may be adjusted based on the feedback of the driver. For example, although it is determined that the driver is in the inattention status when the third reference range determined using the currently determined direction threshold value coefficients is used, if the driver provides feedback indicating that the driver is not in the inattention status, the processor **180** may adjust the direction threshold value coefficients such that the face direction or gaze direction of the driver at the time of wrong determination is included in the third reference range based on the acquired feedback. Alternatively, each driver may set the direction threshold value coefficients via direct input.

In addition, the processor **180** of the artificial intelligence apparatus **100** determines whether the face direction of the driver or the gaze direction of the driver is within the determined third reference range (S**717**).

If the face direction of the driver or the gaze direction of the driver is within the determined third reference range as the result of determination of step S**717**, the processor **180** of the artificial intelligence apparatus **100** determines that the driver is not in the inattention status (S**713**).

If the face direction of the driver or the gaze direction of the driver is not within the determined third reference range as the result of determination of step S**717**, the processor **180** of the artificial intelligence apparatus **100** determines that the driver is in the inattention status (S**707**).

In some embodiments, the processor **180** may determine that the driver is in the inattention status as soon as the face direction of the driver or the gaze direction of the driver is out of the third reference range or may determine that the driver is in the inattention status in consideration of a period in which the face direction of the driver or the gaze direction of the driver is out of the determined third reference range. For example, even if the driver turns their head for less than one second and both the face direction and gaze direction of the driver are out of the third reference range, the processor **180** may not determine that the driver is in the inattention status for such temporary movement. In contrast, when both the face direction and gaze direction of the driver are out of the third reference range for a predetermined time or more (e.g., 3 seconds or more), the processor **180** may determine that the driver is in the inattention status.

If a problem does not occur in the result even when the order of the steps shown in FIG. **7** is changed, the order of the steps may be changed. Similarly, if a problem does not occur in the result even when the steps shown in FIG. **7** are performed in parallel, the steps may be performed in parallel.

The steps shown in FIG. **7** are merely an example of implementing the method of determining the inattention of the driver, and the present disclosure is not limited thereto. For example, the processor **180** of the artificial intelligence apparatus **100** may determine that the driver is in the inattention status, when the speed continuously decreases or increases as compared to the maximum speed of the road on which the vehicle is currently traveling. Alternatively, the processor **180** of the artificial intelligence apparatus **100** may determine that the driver is in the inattention status, when the pressure of the acceleration pedal decreases and the speed of the vehicle continuously decreases or decreases to a predetermined reference value or less in a situation in which the vehicle is traveling on an expressway.

In particular, the processor **180** of the artificial intelligence apparatus **100** may determine whether it is backlight against the driver through the illuminance sensor or based on the brightness of the pixels in the image data. In the case of backlight, since it is not easy for the driver to open their eyes or it is difficult to accurately recognize the gaze direction of the driver, the gaze direction or the degree to which the eyes are closed may not be considered as an element for determining inattention.

FIGS. **8** and **9** are views illustrating examples of a second reference range and a third reference range according to an embodiment of the present disclosure.

The second reference range and the third reference range correspond to the face direction or the gaze direction. (a) of FIG. **8** and (a) of FIG. **9** show the second reference range and (b) of FIG. **8** and (b) of FIG. **9** show the third reference range when the vehicle turns right. That is, (b) of FIG. **8** and (b) of FIG. **9** show the third reference range when the steering angle is in the right direction or when the right turn signal lamp is turned on.

Referring to FIGS. **8** and **9**, the reference range corresponding to the face direction or the gaze direction may include an upward-direction threshold value, a downward-direction threshold value, a left-direction threshold value and a right-direction threshold value. Here, one column may be 30 degrees.

In the second reference range, the right-direction threshold value and the left-direction threshold value are 60 degrees and the upward-direction threshold value and the downward-direction threshold value are 30 degrees. In the third reference range, the right-direction threshold value is 120 degrees, the left-direction threshold value is 90 degrees and the upward-direction threshold value and the downward-direction threshold value are 45 degrees. In this case, the right-direction threshold value coefficient is 2, and the left-direction threshold value coefficient, the upward-direction threshold value coefficient and the downward-direction threshold value coefficient are 1.5.

The reference ranges shown in FIG. **8** are represented by rectangles in an orthogonal coordinates system, because the threshold values are independent of each other. However, the reference ranges shown in FIG. **9** are represented by ellipses instead of the rectangles in an orthogonal coordinates sys-

tem, because the threshold values are dependent on each other. FIG. **9** is merely an example and the reference range corresponding to the face direction or the gaze direction may be represented by various shapes instead of ellipses.

In comparison between FIGS. **8** and **9**, in a situation in which the driver looks at 60 degrees in the right direction and at 30 degrees in the upward direction, it is determined that the face or gaze direction of the driver is within the second reference range in the example of FIG. **8**, but it is determined that the face or gaze direction of the driver is not within the second reference range in the example of FIG. **9**.

FIG. **10** is a view illustrating a relationship between a steering angle and direction boundary value coefficients according to an embodiment of the present disclosure.

Referring to FIG. **10**, the direction boundary value coefficients may be determined depending on the steering angle. In FIG. **10**, the steering angle is represented on the x-axis, the positive direction of the x-axis means the steering angle in the right direction, and the negative direction of the x-axis means the steering angle in the left direction. In addition, one column of x-axis may be 10 degrees. In FIG. **10**, the direction boundary value coefficient may be represented on the y-axis and one column of the y-axis may be 1.

(a) of FIG. **10** shows a relationship **1001** between the steering angle and the left-direction boundary value coefficient and (b) of FIG. **10** shows a relationship **1011** between the steering angle and the right-direction boundary value coefficient. The relationships **1001** and **1002** shown in FIG. **10** may be basic values equally applied to all drivers. The relationships **1001** and **1002** shown in FIG. **10** may be updated later according to the feedback of the driver.

Referring to (a) of FIG. **10**, the left-direction boundary value coefficient may increase as the steering angle increases regardless of whether the steering direction is a left or right direction. The left-direction boundary value coefficient may increase in response to the steering angle more sensitively when the steering direction is the left direction than when the steering direction is the right direction. Similarly, referring to (b) of FIG. **10**, the right-direction boundary value coefficient may increase in response to the steering angle more sensitively when the steering direction is the right direction than when the steering direction is the left direction.

The relationship **1001** between the steering angle and the left-direction boundary value coefficient and the relationship **1011** between the steering angle and the right-direction boundary value shown in (a) and (b) of FIG. **10** are merely one example, and the present disclosure is not limited thereto.

FIG. **11** is a view illustrating a method of updating a third reference range according to an embodiment of the present disclosure.

The method of updating the third reference range may be performed subsequently to the method of determining the inattention of the driver shown in FIG. **5**.

Referring to FIG. **11**, the processor **180** of the artificial intelligence apparatus **100** outputs the inattention alarm (S**1101**). This step corresponds to step S**515** of outputting the inattention alarm shown in FIG. **5**.

In addition, the processor **180** of the artificial intelligence apparatus **100** receives speech feedback of the driver via the microphone **122** (S**1103**).

The speech feedback of the driver may be neutral feedback unrelated to the inattention alarm, such as talking to a passenger or singing a song, positive feedback on the inattention alarm, or negative feedback on the inattention alarm. The neural feedback means that speech feedback on the inattention alarm is not provided, and the positive feedback and the negative feedback provide speech feedback indicating satisfaction with or evaluation of the inattention alarm.

The speech feedback may include implicit speech feedback as well as explicit speech feedback. For example, if the driver makes a negative sound such as sighing, kicking their tongue or yelling, the processor **180** may determine this as negative feedback.

Alternatively, the processor **180** may receive, as feedback, change in expression of the driver in the image data received via the camera **121**. For example, if the driver frowns after the output of the inattention alarm, the processor **180** may receive this as negative feedback.

In one embodiment, the processor **180** of the artificial intelligence apparatus **100** may output speech requesting an evaluation of determination of the inattention status via the sound output module **152** in order to induce the speech feedback of the driver, and obtain speech feedback as the response of the driver.

In addition, the processor **180** of the artificial intelligence apparatus **100** determines whether the received speech feedback is negative feedback (S**1105**).

If the speech feedback is a negative feedback as the result of determination of step S**1105**, the processor **180** of the artificial intelligence apparatus **100** increases at least some of the direction threshold value coefficients (S**1107**).

The direction threshold value coefficients may be set for each driver and are used to determine the third reference range from the second reference range. If the inattention alarm is output but negative feedback is received from the driver in a specific situation, it is necessary to determine that the driver is not in the inattention status. Accordingly, it is possible to widen the third reference range, by increasing at least some of the direction threshold value coefficients used to determine the third reference range.

For example, assume that, in the second reference range, the right-direction threshold value and the left-direction threshold value are 60 degrees and the upward-direction threshold value and the downward-direction threshold value are 30 degrees. In addition, in a situation in which the driver turns on the right turn sign lamp to turn right, the right-direction threshold value coefficient is 2, and the left-direction threshold value coefficient, the upward-direction threshold value coefficient and the downward-direction threshold value coefficient are 1.5. Therefore, assume that, in the third reference range, the right-direction threshold value is 120 degrees, the left-direction threshold value is 90 degrees and the upward-direction threshold value and the downward-direction threshold value are 45 degrees. When the driver turns their head to the left side by 95 degrees in order to view the left window or the left side-view mirror to turn right, the processor **180** may determine that the face direction is out of the third reference range and output the inattention alarm. In addition, if the driver provides negative speech feedback, the processor **180** may increase the left-direction threshold value coefficient from 1.5 to 1.6 such that the left-direction threshold value is changed from 90 degrees to 95 degrees or more in the third reference range.

Since the profile is managed for each driver, the direction threshold value coefficients may be set and updated for each driver. Accordingly, the third reference range may be determined for each driver.

If the speech feedback is not a negative feedback as the result of determination of step S**1105**, the processor **180** of the artificial intelligence apparatus **100** ends the procedure without a separate updating procedure.

However, in some embodiments, the processor **180** of the artificial intelligence apparatus **100** may narrow the third reference range by decreasing the direction threshold value coefficients over time, even if feedback other than negative feedback is received from the driver. If the third reference range only widens based on negative feedback of the driver, there is no method of narrowing the widened third reference range again, and misjudge of false negatives of not recognizing the inattention of the driver may occur even if the driver is actually in the inattention status.

Even if the direction threshold value coefficients decrease over time, a decreased limit may be an initial value. Although each direction threshold value coefficients are managed for each driver, the initial value is set before the direction threshold value coefficients are managed for each driver. That is, the initial values of the direction threshold value coefficients may be equally set for all drivers. In addition, the lower limit of each direction threshold value coefficient over time may be set to an initial value.

FIG. **12** is a view illustrating a relationship between an updated steering angle and a directional boundary value coefficients based on negative feedback according to an embodiment of the present disclosure.

Referring to FIG. **12**, the relationship between the steering angle and the direction boundary value coefficients may be updated based on the negative feedback of the driver. Similarly to FIG. **10**, in FIG. **12**, the steering angle is represented on the x-axis and the positive direction of the x-axis means the steering angle in the right direction, and the negative direction of the x-axis means the steering angle in the left direction. In addition, one column of the x-axis may be 10 degrees. In FIG. **12**, the direction boundary value coefficient is represented on the y-axis and one column of the y-axis may be 1.

(a) of FIG. **12** shows before the relationship between the steering angle and the left-direction boundary value coefficient is updated **1201** and after update is performed by negative feedback of the driver **1202**, and (b) of FIG. **12** shows a basic value **1211** between the relationship between the steering angle and the right-direction boundary value coefficient and a value **1212** updated by negative feedback of the driver. When negative feedback of the driver is received, the processor **180** may not incorrectly determine that the driver is in the inattention status in the same situation, by increasing at least some of the direction boundary value coefficients.

FIG. **13** is a flowchart illustrating an example of step **S511** of determining inattention of the driver shown in FIG. **5**.

FIG. **13** shows an example of the method of determining the inattention of the driver using a neural network based inattention determination model among the methods of determining the inattention of the driver.

Referring to FIG. **13**, the processor **180** of the artificial intelligence apparatus **100** selects an inattention determination model to be used to determine the inattention of the driver (S**1301**).

The inattention determination model may mean a model for determining the inattention of the driver based on the artificial neural network learned using a machine learning algorithm or a deep learning algorithm. The inattention determination model may be classified according to the type of the vehicle and may also be classified according to the driver.

In another embodiment, input of the inattention determination model may include the vehicle type (or vehicle identification information) and driver information (or driver identification information) and thus even a single inattention determination model may determine inattention classified according to vehicles and drivers.

The inattention determination model may be directly learned in the learning processor **130** of the artificial intelligence apparatus **100** and stored in the memory **170**. Alternatively, the learning processor **240** of the artificial intelligence server **200** may learn the inattention determination model, and the artificial intelligence apparatus **100** may receive the learned inattention determination model via the communication unit **110** and store the inattention determination model in the memory **170**.

The inattention determination model may be learned using training data labeled with whether the driver is in the inattention status, with respect to a combination of movement information of various movement driver's seats, driver status information and vehicle status information. The movement information of the driver's seat, the driver status information and the vehicle status information may configure an input feature vector. For example, one training data may include information indicating that the driver is not in the inattention status as label data, and the position of the driver's seat is +3 cm (or 3 cm up), the face direction and gaze direction of the driver are 0 degrees in a vertical direction and 30 degrees in a horizontal direction (or 30 degrees in the right direction), the distance between the eyelids of the driver is 10 mm, and the distance between the lips of the driver is 0 mm as an input feature vector.

The processor **180** may select an inattention determination model corresponding to the vehicle and the current driver among the plurality of inattention determination models stored in the memory **170**. To this end, the processor **180** may identify the driver from the received image data using a face recognition model or a face identification model and select an inattention determination model corresponding to the identified driver. In addition, the processor **180** may select the inattention determination model corresponding to the current vehicle based on the vehicle identification information obtained from the ECU of the vehicle or predetermined vehicle identification information.

In addition, the processor **180** of the artificial intelligence apparatus **100** determines the inattention status of the driver using the selected inattention determination model (S**1303**).

Specifically, the processor **180** may input the generated movement information of the driver's seat, the generated driver status information and the received vehicle status information to the input layer of the selected inattention determination model, and determine whether the driver is in the inattention status based on the output of the output layer of the selected inattention determination model. The inattention determination model determines whether the driver is in the inattention status or not and thus may be implemented as a classification model.

FIG. **14** is a view illustrating a method of determining inattention of a driver according to an embodiment of the present disclosure.

Referring to FIG. **14**, the processor **180** of the artificial intelligence apparatus **100** may obtain (or generate) driver status information such as identification information **1431**, a face direction **1432**, a gaze direction **1433**, a distance between eyelids **1434**, a distance between lips **1435**, by inputting the received image data **1410** to a face recognition model **1420**.

In addition, the processor **180** may select an inattention determination model **1460** corresponding to a driver using the identification information **1431**.

In addition, the processor **180** may determine the inattention of the driver **1470**, by inputting the obtained driver

status information, the movement information **1440** of the driver's seat and the vehicle status information **1450** to the selected inattention determination model **1460**.

FIG. **15** is a view illustrating a method of updating an inattention determination model according to an embodiment of the present disclosure.

The method of updating the inattention determination model may be performed subsequently to the method of determining the inattention of the driver shown in FIG. **5**.

Referring to FIG. **15**, the processor **180** of the artificial intelligence apparatus **100** outputs the inattention alarm (S**1501**). This step corresponds to step S**515** of outputting the inattention alarm shown in FIG. **5** or step S**1101** of outputting the inattention alarm shown in FIG. **11**.

In addition, the processor **180** of the artificial intelligence apparatus **100** receives speech feedback of the driver via the microphone **122** (S**1503**). This step corresponds to step S**1103** of receiving the speech feedback shown in FIG. **11**.

In addition, the processor **180** of the artificial intelligence apparatus **100** determines whether the received speech feedback is negative feedback (S**1505**). This step corresponds to step S**1105** of determining whether the speech feedback is negative feedback, which is shown in FIG. **11**.

If the speech feedback is negative feedback as the result of determination of step S**1505**, the processor **180** of the artificial intelligence apparatus **100** generates training data for update based on the negative feedback (S**1507**).

The processor **180** may generate training data for update, by including a label indicating that the driver is not in the inattention status in the above state according to the movement information of the driver's seat, the driver status information and the vehicle status information, which are used to determine that the driver is in the inattention status, and the negative feedback of the driver. The generated training data for update may be used only to update the inattention determination model corresponding to the driver. Therefore, it is possible to establish an inattention determination model optimized for each driver.

If the speech feedback is not negative feedback as the result of determination of step S**1505**, the processor **180** of the artificial intelligence apparatus **100** determines whether the received speech feedback is positive feedback (S**1509**).

If the speech feedback is positive feedback as the result of determination of step S**1509**, training data for update based on the positive feedback is generated (S**1511**).

The processor **180** may generate training data for update with a label indicating that the driver is in the inattention status in the above status according to the movement information of the driver's seat, the driver status information and the vehicle status information, which are used to determine that the driver is in the inattention status, and the negative feedback of the driver. Similarly, the generated training data for update may be used only to update the inattention determination model corresponding to the driver.

After the training data for update is generated, the processor **180** of the artificial intelligence apparatus **100** updates the selected inattention determination model using the generated training data for update (S**1513**).

The processor **180** of the artificial intelligence apparatus **100** may update the selected inattention determination model, by updating the model parameter of the selected inattention determination model using the training data for update generated directly or using the learning processor **130**.

Alternatively, the processor **180** of the artificial intelligence apparatus **100** may transmit the generated training data for update and the selected inattention determination model to the artificial intelligence server **200** via the communication unit **110**, and the processor **260** or the learning processor **240** of the artificial intelligence server **200** may update the model parameter of the received inattention determination model using the received training data for update, and the processor **180** of the artificial intelligence apparatus **100** may update the selected inattention determination model, by receiving the updated inattention determination model from the artificial intelligence server **200** via the communication unit **110**.

If the training data for update is not generated, the procedure ends without performing a separate update procedure.

However, in some embodiments, the processor **180** of the artificial intelligence apparatus **100** may narrow the third reference range by decreasing each direction threshold value coefficient over time even if feedback other negative feedback is received from the driver. If the third reference range only widens based on negative feedback of the driver, there is no method of narrowing the widened third reference range again, and misjudge of false negatives of not recognizing the inattention of the driver may occur even if the driver is actually in the inattention status.

According to various embodiments of the present disclosure, it is possible to reduce the risk of an accident and provide for the safety of a driver, by providing an inattention alarm upon determining that the driver is in the inattention status while the vehicle travels.

According to various embodiments of the present disclosure, since the inattention status is determined in consideration of different driving habits of the drivers, it is possible to determine the inattention status appropriate for each driver and to increase inattention determination accuracy.

According to various embodiments of the present disclosure, it is possible to determine inattention appropriate for individual drivers, by updating a criterion or model used to determine inattention based on feedback of a driver.

According to an embodiment of the present disclosure, the above-described method may be implemented as a processor-readable code in a medium where a program is recorded. Examples of a processor-readable medium may include hard disk drive (HDD), solid state drive (SSD), silicon disk drive (SDD), read-only memory (ROM), random access memory (RAM), CD-ROM, a magnetic tape, a floppy disk, and an optical data storage device.

Other implementations are within the scope of the following claims.

What is claimed is:

1. An artificial intelligence apparatus for determining inattention of a driver, comprising:

a vibration sensor or a gyro sensor configured to sense movement of a driver's seat of a vehicle;

a camera configured to receive image data including a face of a driver;

a communication modem configured to receive vehicle status information from an ECU (Electronic Control Unit) of the vehicle; and

a processor configured to:

generate movement information of the driver's seat using vibration sensor information received from the vibration sensor or gyro sensor information received from the gyro sensor,

generate driver status information corresponding to the driver from the received image data,

determine whether the driver is in an inattention status based on the movement information of the driver's seat, the driver status information and the vehicle status information, and

output an inattention alarm when the driver is in the inattention status, where the processor is further configured to:

select an inattention determination model to be used to determine inattention of the driver in consideration of a type of the vehicle and identification information of the driver, and

determine inattention of the driver using the selected inattention determination model,

wherein the inattention determination model includes an artificial neural network, and is learned using a machine learning algorithm or a deep learning algorithm.

2. The artificial intelligence apparatus of claim **1**,

wherein the processor is configured to generate, as the driver status information, at least one of identification information of the driver, a face direction of the driver, a gaze direction of the driver, a distance between eyelids of the driver or a distance between lips of the driver from the image data using a face recognition model, and

wherein the face recognition model includes a convolutional neural network (CNN) learned using a deep learning algorithm.

3. The artificial intelligence apparatus of claim **2**, wherein the vehicle status information includes at least one of a speed of the vehicle, a revolution per minute (RPM) of an engine, a transmission gear state, pedal pressure, a steering angle or a lighting state of a turn signal lamp.

4. The artificial intelligence apparatus of claim **1**, wherein the inattention determination model is learned using training data which includes an input feature vector including at least one of the face direction, the gaze direction, the distance between the eyelids, the distance between the lips, the movement information of the driver's seat or the vehicle status information, and a labeled inattention corresponding to the input feature vector.

5. The artificial intelligence apparatus of claim **4**, further comprising a microphone,

wherein the processor is configured to:

receive speech feedback of the driver via the microphone after the inattention alarm is output,

when the speech feedback is negative feedback, generate training data for update based on the negative feedback,

when the speech feedback is positive feedback, generate training data for update based on the positive feedback, and

update the inattention determination model using the generated training data for update.

6. A method of determining inattention of a driver, comprising:

sensing movement of a driver's seat of a vehicle using a vibration sensor or a gyro sensor;

generating movement information of the driver's seat using vibration sensor information received from the vibration sensor or gyro sensor information received from the gyro sensor;

receiving image data including a face of a driver from a camera;

generating driver status information corresponding to the driver from the received image data;

receiving vehicle status information from an ECU (Electronic Control Unit) of the vehicle;

determining whether the driver is in an inattention status based on the movement information of the driver's seat, the driver status information and the vehicle status information; and

outputting an inattention alarm when the driver is in the inattention status,

wherein the determining whether the driver is in the inattention status comprises:

selecting an inattention determination model to be used to determine inattention of the driver in consideration of a type of the vehicle and identification information of the driver, and

determining inattention of the driver using the selected inattention determination model

wherein the inattention determination model includes an artificial neural network, and is learned using a machine learning algorithm or a deep learning algorithm.

7. A non-transitory recording medium stored thereon a computer program for controlling a processor to perform a method of determining inattention of a driver, the method comprising:

sensing movement of a driver's seat of a vehicle using a vibration sensor or a gyro sensor;

generating movement information of the driver's seat using vibration sensor information received from the vibration sensor or gyro sensor information received from the gyro sensor;

receiving image data including a face of a driver from a camera;

generating driver status information corresponding to the driver from the received image data;

receiving vehicle status information from an ECU (Electronic Control Unit) of the vehicle;

determining whether the driver is in an inattention status based on the movement information of the driver's seat, the driver status information and the vehicle status information; and

outputting an inattention alarm when the driver is in the inattention status,

wherein the determining whether the driver is in the inattention status comprises:

selecting an inattention determination model to be used to determine inattention of the driver in consideration of a type of the vehicle and identification information of the driver, and

determining inattention of the driver using the selected inattention determination model,

wherein the inattention determination model includes an artificial neural network, and is learned using a machine learning algorithm or a deep learning algorithm.

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